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Number 3

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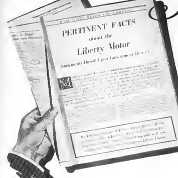

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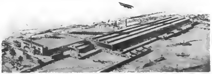

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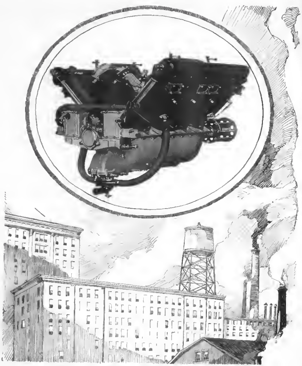


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"The Motor that made the Spad possible"
for the war-time equipment of thousands of combat, pursuit and training 'planes, hydro's and dirigibles in the United States Government Air Program.
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1
2
SECTIONS 4 and 5
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As a preliminary step toward the development of commercial aviation in Canada, the United Aircraft Engineering Corporation, acting for a syndicate, has purchased from the Imperial Munitions Board of Great Britain the entire flying equipment of the Royal Air Force in Canada, with the exception of those few planes which the Dominion is retaining as a nucleus for future Military aeronautical development. The equipment purchased was originally valued at close to ten million dollars.

United Aircraft Engineering Corporation
52 Vanderbilt Avenue
New York

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The Commercial Aeroplane
IS HERE

Let those who discuss the FUTURE of the commercial aeroplane, bear in mind that there exists the commercial aeroplane of the PRESENT for the commercial aeroplane is already here.

THE CANTILEVER AERO COMPANY is the builder, the KERR STEAMSHIP COMPANY, INC., 17 Battery Place, New York City, the purchaser, and the CHRISTMAS "BULLET" which will henceforth fly the Kerr flag is the plane.

There is something dramatic and unique in the first adaptation of the aeroplane to modern business. The purpose of this aeroplane is to overtake a ship, many miles at sea and deposit a regulation mail sack upon her deck. It frequently happens that a ship in order to maintain a schedule and to clear the dock for inbound traffic must leave port before important and valuable despatches are ready. The expense of delaying sailing is enormous—the inconvenience is great and if the ship is missed, there is nothing to do but wait for another. The entry of the aeroplane into serious commercial work has changed all this.

With an eye to the FUTURE POTENTIALS of the aeroplane, the KERR STEAMSHIP COMPANY decided not to overlook its PRESENT POSSIBILITIES. The fast aeroplane that can overtake a ship a day out at sea with one or more sacks of belated mail or despatches has literally reduced the sailing time of every outbound ship by many hours, and there are other means by which fast aeroplanes can supplement the service of a steamship company. THE CANTILEVER AERO COMPANY is gratified that its product was selected for this exacting duty and is proud to be a contributing factor to this NEW ERA OF TRANSPORTATION. THE CHRISTMAS "BULLET" designed by DR. WILLIAM WHITNEY CHRISTMAS is a strutless biplane, equipped with FLEXIBLE WINGS and makes a speed of upwards of 180 miles per hour. It has a high safety factor, lands easily, and is built for duty throughout. It is the purpose of the CANTILEVER AERO COMPANY to continue the manufacture of the highest type of aeroplane, knowing that it will render the only kind of service that will survive the demands that commerce is soon to make upon the ship of the air.

SAFETY SPEED PERFORMANCE

THE AEROPLANE IS A PRONOUNCED SUCCESS AND HAS COME TO STAY. Its field of development and usefulness knows no horizon. Over all parts of the world this great mechanical bird will soon spread its wings, and unexplored regions will be a memory.

THE UNITED STATES OF AMERICA IS THE BIRTHPLACE OF THE AEROPLANE. It is to be expected that this country of boundless resources and vast distances which developed the automobile to its present degree of usefulness will be equally energetic in encouraging the development of this latest child of its national invention. AS A WEAPON OF WAR its value is unquestioned. AS A MEDIUM OF TRANSPORTATION ITS FUTURE IS ASSURED.

CONSIDER WELL THE ADAPTABILITY OF THE AEROPLANE TO YOUR BUSINESS. IT IS HERE TO MEET EVERY DEMAND. In the past the miner carried his precious pack on the back of a burro, through winding mountain passes beset by many dangers, travelling day and night against nature's greatest obstacles, in order to bring his product safely to its destination. The aeroplane will change all this because it will eliminate distance and winding paths and rushing rivers will quickly fade in the wake of its swift flight.

THE RANCHER WILL INSPECT HIS RANCH FROM THE AIR where his horizon is governed entirely by his altitude and with the help of a good pair of binoculars the ground is brought within two feet of his searching eye and things on the surface can be minutely inspected—and all of this with absolute ease and comfort.

THE OIL INDUSTRY SHOULD NUMBER AMONG THE FIRST TO RECOGNIZE THE ABSOLUTE NECESSITY OF THE AEROPLANE. Repairs can be quickly made, pay rolls safely carried and trips of inspection made with greatest despatch.

IN A SHORT WHILE THE AEROPLANE WILL BE USED FOR ALL COMMERCIAL PURPOSES but it is ready now to answer the call of these industries already mentioned.

THE CHRISTMAS BULLET IS A FLEXIBLE WING AEROPLANE which permits it to take off in a small space at a low speed and land under similar conditions. It is also automatically stable and easily controlled although its speed range is up to 200 miles per hour. THE CANTILEVER AERO CO. IS READY TO CONSTRUCT AEROPLANES SUITABLE FOR ANY BUSINESS DEMANDS from the small high speed Christmas Bullet Scout to the large high powered, high speed, heavy weight carrying TRANS-CONTINENTAL OR TRANS-OCEANIC FLIER.

We would like to tell you why the aeroplane will improve your service. It is only a matter of time before you are going to realize the necessity of using it. Why not get acquainted now?

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Stainless Steel Motor Valves

Meeting War Requirements Develops Valve Material Ideal for Many Motors

STAINLESS STEEL was originally used experimentally by Hadfield, as a valve material in certain English motors and for other parts in which non-oxidizing qualities were desired.

Then came the war. European airplane motor parts had to be produced in America. Stainless Steel valves were wanted on a large scale production basis for these high compression motors. Later some French and other foreign airplane motors built in this country turned to Stainless Steel as a remedy against burning and warpage of valve seats when war necessities demanded motors of greater ceiling power, consequently, higher compression and greatly intensified motor heats.

During the last two years we have satisfactorily produced thousands of these valves to fill this demand and were able to do this because of extensive inquiries made into the properties of this steel in our laboratories and thorough tests made of its service qualities resulting in definite determination of the proper methods and processes to be followed in forging and heat treating the steel.

This steel, therefore, is in no sense experimental either from the viewpoint of manufacturing or service It offers, we believe, an ideal valve material for many motors. Even when operating at high motor heat, valves of this steel

—Withstand oxidation.
—Hold their hardness.
—Maintain their strength.
—Have good wearing and seating qualities.

Fusing, burning, warpage, loss of power and similar troubles are practically negligible.

Attention is invited to this valve material as one which holds possibilities for securing high efficiency in many motors, presents opportunity to test a possible remedy for valve difficulties, if existing, and enabling motor engineers, if desired, to increase motor power without decreasing valve efficiency.

We have further data which we will be glad to present on request.

The Steel Products Co.

Cleveland Detroit

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IGNITION

When The Thermometer's Down

—A turn of the switch to "H" will start that chill-dulled motor in a jiffey A thousand sparks a second pour into each cylinder in firing order and where is the motor in *any* weather that can resist this flaming shower?

That is the Philbrin High Frequency System—the emergency unit of the Philbrin Duplex Ignition. You use it to meet abnormal conditions, when carburetion is faulty, fuel is poor, plugs are fouled, starting is difficult—whenever the engine shows signs of stubbornness

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An airplane engine deserves the best there is in ignition systems It deserves *Philbrin.*

Used by the Aeronautic Division of the United States Navy

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MARCH 1, 1919 **AVIATION AND AERONAUTICAL ENGINEERING** VOL. VI. NO. 3

Member of the Audit Bureau of Circulations

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AVIATION AND AERONAUTICAL ENGINEERING

ALEXANDER KLEMIN, TECHNICAL EDITOR
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Vol. VI March 1, 1919 No. 3

THE Aeronautical Exposition, coming as it does at the most critical period of this country's aviation history is bound to have great influence on the future. Congress has given the aeronautical industry an impetus through large war time appropriations and this progressive attitude is reflected by the products exhibited. Our country is now ready to produce the best airplanes in the world—given the opportunity.

Both the Army and Navy have carefully prepared aircraft programs which are dependent on the organization and appropriation bills for next year.

Before the war, Congress was not convinced that the airplane would play an important role in warfare and begrudgingly gave it meagre support. Now, however, with the facts of the military and naval value of aircraft clearly demonstrated, there can be no excuse for placing the blame elsewhere.

The development of commercial aviation is receiving serious consideration by trained engineers. They have certain definite information to guide them. The field, however, is a new one and will have to be charted carefully so that no misstep be made. Ill considered ventures on impracticable lines will tend to retard rather than help the growth of aerial transportation. Therefore, sound business judgment should guide the early attempts to commercialize the air.

The sporting use of the airplane will undoubtedly become widespread ere long owing to the numbers of trained pilots released from service. These fliers not only have the skill to make competitions thrilling, but also have faith in the safety of aircraft. They will, by their flying, make the air a popular sporting area.

The Exhibition will have accomplished its purpose if it has encouraged these things, and the Manufacturers' Aircraft Association deserves great credit for making such a show possible at this time.

Possible Types of Commercial Machines

In the development of commercial machines, two schools of thought have apparently arisen.

Some designers maintain that if commercial aeronautics is to become a practical achievement, utility and not comfort will be the paramount necessity. It is quite true that with present designs, airplane travel is not altogether pleasurable. The passenger when not protected by an adequate wind shield is almost fully exposed to the blast of the wind. He may at the end of a trip be covered with oil. Exhaust gases and the noise of the propeller add to his discomfort. Even on comparatively large two seater machines, the cockpit is far from roomy, and it is not pleasant to be muffled up to the ears, incased in a leather flying suit.

To offset these disadvantages, speed and yet more speed is claimed to be a necessity. As an illustration, some recent machines have attained a maximum ground level speed of 150 m. p. h. Two hundred miles an hour will soon be realized. With such speeds a real saving of time would be attained by the business man on a trip of 300 or 400 miles, even when considering the time employed in going to a flying field at the beginning of the trip, and in reaching the city from the flying field on arrival—the so-called terminal delays—for the business man would, in view of this saving of time, overlook the many minor discomforts of air travel.

To attain speeds of anything like the above values, a special type of machine will be evolved. It will probably be a machine not carrying more than one passenger, single motored, with only a moderate amount of wing area, and consequently a high landing speed. To reduce parasite resistance to a minimum, the body must be of the smallest possible cross section, and therefore provide only little seating room. Since a comparatively small machine must be employed, only one engine can be carried.

The second school of commercial airplane design believes that the time has now come where serious thought should be given to the comfort of the passenger. And the following type is now broadly outlined. A multi-engined machine, of two or preferably three motors, so that in the case of one motor giving out, the trip can be completed on half or two-thirds the full power. The speed to be attained does not exceed 100-110 m. p. h. In a roomy central nacelle or fuselage, a fairly large number of passengers can be carried. The body of large machines has now such a depth and width that the occupants can be entirely enclosed and move around. Since only a moderate speed is desired, the designer can employ large wing areas with a slower landing speed. The stability in the air is increased by virtue of size alone, apart from any other features in design. Since a large machine is harder to maneuver rapidly, structural factors of safety need not be so high. The pay of a pilot and pilot-mechanic is distributed among a large number of passengers. This type suffers, however, from the drawback that it requires vast landing fields, large hangars, and larger emergency landing fields.

One designer intends to take his small ship and increase its size while maintaining its enormous speed. The other employs the larger machine and attempts to add to the comfort and greater safety of his design, by introducing aerodynamic and structural refinement.

The question of the right type is far from being settled, and it will be interesting to watch new designs which will naturally fall into these two categories.

Present Status of American Airplane and Seaplane Construction

By Alexander Klemin

In the present transitional state of the industry it seems very interesting to present data on existing American practice, both as regards machines of purely American design, and machines of foreign design rebuilt or redesigned in this country. A study limited to American construction may not give as wide a field for the construction of performance curves for

Lepère Two-Seater Fighter, 300 Hp Hispano-Suiza Engine

different weights per horse-power and different loading per square foot, but data on types with which the designer is familiar mean a great deal more to him for comparative purposes, than data on types which he has viewed through a photograph or two. Moreover, examining what has been done

Vought Advanced Training Biplane, 150 Hp Hispano-Suiza Engine

in the United States, we come to the conclusion that the entire field of land machines has been fully covered with examples quite as good as those of foreign practice.

In the single seater scout perhaps we have lagged, but there are now several good machines of this type under construction. In seaplanes it may be said that the United States actually lead. It is in fact possible to state that American practice is on a footing of equality with European practice; in the two-seater fighter type at least two American machines show a wonderful superiority over any existing European type. All the data collected is presented in the appended chart. It is hoped that this is fairly representative and complete. If any good machines have been omitted, it is because performance data on these machines are not available.

Land Airplanes

The Small Single-Seater.—This type has almost entirely been neglected during the war. But a single machine is presented which is of recent construction and for this no tests are available. With a 45 hp. engine it seems possible, with a power loading of 12.7 lb. per hp. and a wing loading of 5.65 lb. per sq. ft. to carry a 30 per cent useful load, with a range at full power of 2 hr. Given moderately skilful design, it should under these conditions be possible to secure a low landing speed, and a speed and climb surpassing that of the JN-4 with a 100 hp. motor. The type, though quite useless for military purposes, would seem therefore to offer possibilities for commercial and pleasure use.

Single-Seater Training Type.—With 80 hp. from a rotary engine, it is possible to get comparatively great speed and climb, and very rapid maneuverability. As training ships for military pilots these airplanes have rendered the greatest possible service. For civilian use, the only application they can have is for the use of pilots who wish to use them as stunt machines. Their high landing speed, and extremely sensitive control puts them out of reckoning as far as ordinary civilian flying is concerned. As a technical offset to their high landing speed, it is wonderful what can be done with a loading of 14.8 lb. per hp.—namely, a maximum speed of 100 m.p.h. at ground level.

Two Seater Training—Primary and Advanced.—This may

very well be subdivided into two classes. The plane with 90 to 100 hp., and the plane with 150 hp., although in most cases the low-powered machine has been but very slightly redesigned to take the more powerful engine. The low-powered type, such as the Curtiss JN-4D with the Curtiss OX-5 engine, has

Loening Two-Seater Fighter, 300 Hp Hispano-Suiza Engine

done yeoman service for the training of pilots. It is also a satisfactory machine for private flying, though somewhat slow in performance. If improvements are made in this type both as regards better streamlining, and better structure—these machines have practically retained their pre-war characteristics—they should give real civilian usage. The 150 hp. type carries at present an expensive and delicate engine, but given one of slightly more rugged construction, they would form a handy instrument for pleasure flying. The V.E.7 is a particularly

Curtiss Pursuit Triplane, 400 Hp Curtiss Engine

interesting example, and with a weight of 11.4 lb. per hp. shows a maximum ground speed of 116 m.p.h.

Single-Seater Pursuit.—The Spad and S.E.5 are very representative types, still in wide use at the end of the war, although they were being rapidly replaced by single seaters carrying 300 hp. engines. With their extremely high loading and landing speed, these machines present none but military interest.

The Two-Seater Fighter, Reconnaissance or Day Bomber Type.—One of the machines enumerated in our chart, the DH4, with slight modifications, is being used successfully for mail service. It is true that accidents on landing occur, the landing speed being too high, nevertheless the immediate utilization of this type shows that it has possibilities in peace time. One very interesting feature of the tabulated performance is the tremendous superiority of the Curtiss Triplane and the Loening Monoplane over the DHs and the Lepère. Without going to higher engine power, the designers of these two machines have achieved a real step forward as regards efficiency. In the Curtiss Triplane this has been done by the last refinement in streamline. In the Loening a skillful utilization of the monoplane has resulted in the elimination of interplane bracing and parasite resistance. These two airplanes mark an epoch in American design.

Night Bombers.—These machines, capable of carrying ten or more passengers, and equipped with multiple engines, are capable of flight with part of the power plant out of commission at a relatively small landing speed, they deserve for this reason careful study from a peace point of view. Utilized in warfare for night raids, far behind the lines, they have also a much greater range than the smaller two seaters. The type could be utilized for both mail service and passenger work.

The Glenn Martin Bomber, with a higher power loading than the Caproni, shows a marked superiority both in speed and climb. It has to yield as far as performance goes to the English DH 10A, which is included for purposes of comparison. It is interesting to note that these very large ships are not far behind the two seaters in both speed and climb, at least not far enough to constitute a serious drawback in view of the distinct advantages the multiple engine type possesses for commercial utilization.

It would seem on the whole that for land machines, we have a sufficient variety of types to draw upon, and but slight modifications to make to cover the immediate requirements of peace work.

Seaplanes

The work of the Navy has been even more silent than the work of the Army. Commander H. C. Richardson's paper before the S. A. E. was perhaps the first announcement giving a classification of the Navy's planes and their different function. Corresponding to the land single seater training planes, a certain number of Gnome engine sea-going scouts were used, such as the Curtiss and the Thomas.

Naval Seaplane NC-1, Three 330 Hp. Liberty Engines

Most of the training was done however with two seater machines, such as the Curtiss N-9, the R6, the Aeromarine and Boeing seaplanes. The N-9, after the substitution of the Hispano for the Curtiss Oxx 100 hp., was particularly successful. The Curtiss F boat, originally developed for sporting purposes, also underwent but slight modifications before being available for instruction purposes. Except for the single seater scouts, all the small Navy boats are just as useful as pleasure ships.

The large submarine patrol and convoy machines have undergone a wonderful development during the war. The NC-1 for instance with its great range, enormous useful load, and fuel capacity is a wonderful product, immediately capable of commercial application. It is interesting to note that after the long debate as to the sea going qualities of the float seaplane and the flying boat, the flying boat has eventually come to be used almost exclusively. This applies in particular to large size machines.

Loening "Kitten," Probably the Smallest Seaplane in Existence. Span 22 Ft. Chord, 5 Ft. Length, 16 Ft. Gross Weight Including Pilot and 2 Hr. Fuel 650 Lb. Engine, 35 Hp. Lawrance. The Machine Has Shown Very Satisfactory Performance in Speed Range and Climb

Naval Seaplane F-5-L, Two 330 Hp. Liberty Engines

Glenn L. Martin Night Bomber, Two 400 Hp. Liberty Engines

Spad C-1 Pursuit Biplane, 180 Hp. Hispano-Suiza Engine

Handley-Page Night Bomber, Two 400 Hp. Liberty Engines

SE-5A Pursuit Biplane, 200 Hp Hispano-Suiza Engine

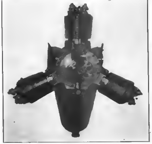
Caproni Night Bomber, Three 400 Hp Liberty Engines

The Lawrance 3-Cylinder Airplane Engine

The Lawrance 3-cyl. airplane engine is intended for use on sport type machines to carry either one or two people, and has been designed especially to fill this need. It has been worked out with the idea that a man who wished to take care of his airplane must have the minimum work to do in order to keep it in good condition. Therefore, it has been found advisable to design an engine with only three cylinders and arrange it in such a way that all the parts which need attention are readily accessible.

The performance curve shows that this engine develops 41.5 hp at 1200 r.p.m., 47 hp at 1400 r.p.m., and 52.5 hp at 1600 r.p.m. The bore is 4.25 in., the stroke 5.25 in.

The crankcase and air-cooled cylinders are of aluminum, this metal being used on account of its high conductivity which is very desirable for air-cooled engines. The crankcase



Lawrance 35 Hp Airplane Engine

contains a single throw crankshaft of chrome nickel steel on which the three connecting rods work, and the reciprocating and rotary forces are counter-balanced by a pair of balance weights. This gives a very good balance far superior to the four cylinder automobile type of engine.

Cylinders are of cast aluminum with air-cooling fins machined on them, and with the head integral with the cylinder. In the head is cast a bronze seat for the valves. This bronze seat has been found very satisfactory, requiring grinding very seldom, and on account of the coefficient of expansion of the two metals being very nearly alike, there is very little danger of its breaking loose with the expansion and construction of the cylinder at different temperatures.

The valves, one inlet and one exhaust, are mounted in the head at a slight angle with the bore. They are both hollow, and the exhaust valves are treated with mercury in order to assist in cooling the heads of the valves. They work in bronze guides in the head of the cylinder. Here again bronze is used instead of iron because its conductivity is greater. The valve springs are of a new type. They are made of a flat ribbon of steel which is tapered so that its width is considerably less at one end than at the other. It is then rolled into a spiral, the wide part of the ribbon forming the outer coils. This gives a spring which has a very short overall length, and in which all the coils are stressed equally.

The steel liners are pressed into the cylinder by a hydraulic press. They are $\frac{1}{16}$ in. thick, and case hardened and ground in place making a very fine wearing surface for the pistons which are of the ordinary round type with flat heads, and they have four $\frac{1}{8}$ in. rings at top and one wiper ring at the bottom of the skirt.

The wrist pins are of the full floating type, and are kept from coming in contact with the walls of the cylinder by two bronze buttons which are pressed into their ends. The connecting small end is bushed with Non-Gran bronze, and the rod itself is a hollow round rod drilled from the top end. The big end of the rod is in the form of a segment of a circle, and fits in two grooves in the bronze bearing on the crankpin in a somewhat similar way to the method used on the Le Rhone rotary engine, except in this case the crankshaft is made all in one piece, and the bronze bushing is split and bolted together with four bolts.

The propeller hub is mounted on the crankshaft on a taper of very ample proportions, and is pulled very tightly into place by means of a differential thread. On account of the generous proportions of these parts chafing of the propeller shaft and hub is never experienced.

The valves are operated by means of three individual camshafts, one for each cylinder, which are also used to drive various auxiliaries such as oil pump, distributor, tachometer. These camshafts operate the cam followers with rollers and a push rod having a ball at each end. One of these balls is adjustable for valve clearance. On the end of the rocker arm which operates the valve is a small roller, which obviates any side thrust against the valve guide. On account of the expansion of the cylinder, the valve clearance varies very considerably, and the camshafts are so designed that the rollers attack the cams for the proper timing with .060 in. clearance. In order to obtain this clearance when hot, it is necessary to adjust for .015 in. when cold.

The oiling system is interesting in that the manufacturer employs a system whereby the crankpin is oil cooled. Oil under pressure is forced through the shaft and a certain amount escapes at the various bearings for lubrication purposes. The remainder flows through a hole at the front end of the shaft, and passing through a ball check which maintains it at the desired oil pressure returns to the cylinder. The sump or oil tank is integral with the motor, being fastened to the pump by the crankcase. The oil runs by gravity into this sump which on account of its exposed position is well cooled by the air stream. The oil is pumped through an ample strainer which can be removed very easily for cleaning purposes, and returns to the pump.

Two forms of ignition are used on these engines, namely, a special magneto, which was designed for this job by Mr. Kliesrath, the engineer of the Simms Magneto Co., or the Philbrin battery ignition. Both of these systems are of interest as in both cases two plugs fired absolutely simultaneously only one breaker being used at a time. In case of the magneto the armature has one primary wiring but two high tension wirings and a separate distributor, the magneto running at $1\frac{1}{2}$ times engine speed, and the distributor at $\frac{1}{2}$ engine speed. This high speed of the magneto makes starting easy, and the magneto can be reduced to the smallest possible proportions, weighing in this case $7\frac{1}{2}$ lb.

The Philbrin ignition runs at one-half the engine speed and consists of two separate primary breakers, two high tension distributors, and two coils. By means of a switch either breaker can be put in use, operating both coils and both high tension distributors. Equipped with this system with a 20 ampere hour storage battery, the engine weighs two pounds more than equipped with a magneto. The weight of the motor is 130 pounds with magneto and 132 pounds with the Philbrin system. This weight includes everything ready to run including the propeller hub. It does not, however, include the oil tank which weighs five pounds additional.

The question of mounting an engine of this sort is very important and considerable experiment was carried on before the system illustrated herewith was adopted. It is a great advantage to distribute the stresses over various parts of the crankcase.

The carburetor used is a Miller $1\frac{3}{4}$-in. type with barrel throttle having an altitude adjustment by which the level in the float chamber can be varied to suit the conditions.

Characteristics of American Built Airplanes, Seaplanes and Flying Boats

Government Department or Manufacturer	Type	No. of Crew	No. and Make of Engines	Horsepower at r.p.m.	Weight of Engine (lb.)	Weight of Radiator and Cooling Water (lb.)	Gross Weight (lb.)	Weight Empty with Water (lb.)	Fuel and Oil (lb.)	Military Load (lb.)	Crew (lb.)	Total Wing Area incl. Ailerons (sq. ft.)	Wing Curve	Wing Loading (lb. per sq. ft.)	Power Loading (lb. per h.p.)	Performance: Speed (m.p.h.)	Performance: Level (ft.)	Performance: Climb (min.)
1.—Small Single-Seaters.																		
U. S. Martin	K-III (Bi.)	1	1 Gnat A.B.C.	45 / 1950	55 8	(air)	571 0	350	51 9		170	108 3		5 66	12 7			
2.—Single-Seater Training Machines.																		
Ordnance	Scout (Bl.)	1	1 Le Rhone	80 / 1200	300	(air)	1161	848	120	0	170	160	R.A.F. 15	6 5	11 [illegible]	96	10000	30' 20"
Standard	E1 (Bi.)	1	1 Le Rhone	80 / 1200	301	(air)	1188	861	130	[illegible]	170	153	R.A.F. 15	7 73	14 8	100 95 90 85	0 3500 8500 10000	0 5'
Thomas-Morse	S4C (Bl.)	1	1 Le Rhone	80 / 1200	310	(air)	1300				170	[illegible]		5 4	15	95	0 5000	0 10'
C.S.A. Bristol	Scout (Bl.)	1	1 Le Rhone	80 / 1200		(air)	1175	780			180	204		5 [illegible]	14	98 7 93 75	0 6500 16500	0 11' 45" 30' 30"
3.—Single-Seater Pursuit Machines.																		
Curtiss	S-E5 (Bi.)	1	1 Hispano-Suiza	170 / 1700			2060	1485	180	15[illegible]	180	4[illegible]		8 1	11 1	121 5 120 117 101	0 6500 10000 15000	0 1 13 22' 10"
Curtiss	[illegible]	1	1 Hispano-Suiza	300 / ?			1853			[illegible]		[illegible]				126 121	0 6500 10000 15000	0 6 11 21
Curtiss	[illegible]	1	1 Hispano-Suiza	300 / 2150			1820		110			[illegible]		8 15	8 1	133 127 125 118	0 5500 10000 15000 20000	0 1' 40" 8 16' 20"
4.—Two-Seater Training Machines. *(Primary)*																		
Curtiss	JN 4D (Bi.)	2	1 Curtiss OX5	90 / 1400			1 [illegible]	1430	140		330	352 5		5 [illegible]	[illegible]			
Standard	J1 (Bi.)	2	1 Curtiss OX5	92 / 1500	434	108	2070	1557	183		330	439	R.A.F. 1	4 8	[illegible]	70 0	3700 6502 10000	10 30½ 50
(Advanced)																		
Curtiss	JN 4H (Bi.)	2	1 Hispano-Suiza	150 / 1400			2145	1565	220		80			[illegible]	14 [illegible]			
Standard	JR1	2	1 Hispano-Suiza	150 / 1800	452	116	2160	1460	207		350	10	U.S.A. 5	5	11 8	86	0 6300 10000 15000	0 10 20 52
Standard	E4	2	1 Hispano-Suiza	170 / 1700	452	149 5	2200	1502	264	94	340	332	R.A.F. 15	6 [illegible]	13 5	160	0 5650 10000	0 10 22
Vought	VE-7	2	1 Hispano-Suiza	170 / 1706			1908	1382	181		360	291		8 5	11 1	110 111 105 100 94	0 5000 10000 15000 20000	0 5 3" 11 30" 22 48
5.—Two-Seater Fighter, Reconnaissance, or Day Bomber Machines.																		
Dayton-Wright	DH-4A (fighter)	2	1 Liberty 12-A	397 / 1700	801	240	3792	2391	457	450	354	440	R.A.F. 15	8 6	9 45	120 5 118 114 107	0 6500 10000 15000	13 45"
Dayton-Wright	DH-4A (bomber)	2	1 Liberty 12-A	397 / 1700	801	240	3888	2391	457	619	354	440	R.A.F. 15	9 1	10 1	117 3 112 107 85	0 6500 10000 15000	0 17
U. S. A.	DH-9A (rec.)		1 Liberty 12-A	397 / 1700	910		4521	2810	983	427	360	490	R.A.F. 15	9 2	11 3	126 120 107	6500 10000 15000	0 16' 40"
U. S. A.	DH-9A (day bomber)	2	1 Liberty 12-A	397 / 1700	910		4872	2815	983	704	360	490	R.A.F. 15	10 2	12 5	121 116 114 85	0 6500 10000 15000	0 18 32½

Type	Ceiling (ft.)	Span	Chord	Gap	Incidence of Wings (deg.)	Dihedral (deg.)	Sweepback (deg.)	Decalage (in.)	Stagger (deg.)	Length (ft.)	Height (ft.)	Area of Stabilizer (sq. ft.)	Area of Elevator (sq. ft.)	Total Aileron Area (sq. ft.)	Area of Fin (sq. ft.)	Area of Rudder (sq. ft.)	Total Vertical Area (sq. ft.)	Fuel Capacity (gal.)	Oil Capacity (gal.)	Landing Speed (m.p.h.)
K-III (Bi.)		18 / 15	3' 6"	4' 0"		0	0	0	0	13' 2"	7' 4"	8 5	6 7	5 0	0	4 0	4 0	9		
Scout (Bl.) (Ordnance)	[illegible]	25 / 25	40	40"		0	0		0"			12	12 [illegible]		2 0	0 8	8 4			
E1 (Bi.)	[illegible]	[illegible]4	3' 6"	4	[illegible]	2	0	0	15	18' 10"	6' 7"	12	12 7	23 2	2 0	6 8	8 4	29 5	5	
S4C (Bl.)		26' 7" / [illegible]	60 / 51	54	2½	0	0	0	32	18' 9"	8' 7"			86						
Scout (Bl.) (C.S.A. Bristol)	[illegible]	[illegible]	4' [illegible]	4' 5"						20' 5"	8' 8"									
S-E5 (Bi.)	[illegible]			4' 10"																
Curtiss [illegible]	[illegible]																			
Curtiss [illegible]	[illegible]									20' 4"	[illegible]									
JN 4D (Bi.)	[illegible]		1' 11"	[illegible]						27' 4"	8' 11"									
J1 (Bi.)	[illegible]	[illegible]							6	26' 7"	10' 3"	21 7	[illegible]	[illegible]	[illegible]	11	13 7	31	4	38 3
JN 4H (Bi.)	[illegible]																			
JR1	[illegible]	[illegible]							6	[illegible]	10' 10"	23 7	[illegible]	34	1 7	10	13 7	41	3	42
E4	[illegible]	[illegible]							5½	26' 2"	9' 8"	23 7	22	46 0	4 0	10 1	11 7	45	1	
VE-7	[illegible]	34	[illegible]	[illegible]					11	22' 4"	8' 7"	19	17	37 1	[illegible] 4	7 8	10 5	41	3	
DH-4A (fighter)	[illegible]	42	5' [illegible]	5' 6"	1	[illegible]		1	1°	29' 11"	9' 6"	38 5	24	70 56	0	13 5	18 5	88	10	
DH-4A (bomber)	[illegible]	42' [illegible]	[illegible]	5' 1"	1		1	0	12	29' 11"	9' 8"	38 5	24	70 56	0	13 5	18 5	88	10	
DH-9A (rec.)	[illegible]	4[illegible]' 11"	[illegible]	6' 1"	1	3	0	0	12½	30' 3"	10' 8"	30 1	23 6	72 28	5 2	13 5	18 7	142	14	
DH-9A (day bomber)	[illegible]	4[illegible]' 11"	[illegible]	6' 1"	1	3	0	0	12½	30' 3"	10' 8"	30 1	23 6	72 28	5 2	13 5	18 7	142	14	

Characteristics of American Built Airplanes, Seaplanes and Flying Boats—Continued

Government Department or Manufacturer	Type	No. of Crew	No. and Make Engines	Horsepower at r.p.m.	Weight of Engine (lb.)	Weight of Radiator and Cooling Water (lb.)	Gross Weight (lb.)	Weight Empty with Water (lb.)	Fuel and Oil (lb.)	Military Load (lb.)	Crew (lb.)	Total Wing Area, incl. Ailerons (sq. ft.)	Wing Curve	Wing Loading (lb. per sq. ft.)	Power Loading (lb. per h.p.)	Performance: Speed (m.p.h.)	Performance: Level (ft.)	Performance: Climb (min.)
L. W. F.	G-2 (Bl.)	3	1 Liberty-12-K	410 / 1800			4023	2708	327	302	360	516	L.W.F. 1	7.8	9.3	130 / 100	0 / 10000	9' 3"
U. S. A. Bristol	U.S. B-1 (Bl.)	2	1 Hispano-Suiza	310 / 1800	506		2910	1842	344	364	360	229		7.83	5.7	113.0 / 100.0 / 101	5000 / 10000 / 15000	5' 30" / 10' 05" / 16' 30"
Packard-Lepere	C-II (Bl.)	2	1 Liberty-12A	397 / 1700	800		3746	2561	483	341	360	410.4	Sopw.	9.06	9.06	130.4 / 127.0 / 122.4 / 84	5000 / 10000 / 15000 / 20000	4' 15" / 9' 20" / 17' 30" / 30' 35"
Curtiss	18-T (Tri.)	2	1 Curtiss-K-12	400 / 2250	740		2900	1825	445	301	330	309	S.A.C. 68	9.4	7.25	161	0 / 12135	0 / 10
Loening	(Mon.)	2	1 Hispano-Suiza-H	340 / 1800	610	140	2500	1520	380	300	330	230		10	7	114.5	20000 / 24000	36 / 32
U. S. A.	DH 10-A (Bl.)	2	2 Liberty-12	397 / 1700			6000	5000	1420	307	360	837		15.0	10.7	114.0 / 100	10000 / 18000	[illegible]

6.—Night Bomber Machines

Government Department or Manufacturer	Type	No. of Crew	No. and Make Engines	Horsepower at r.p.m.	Weight of Engine (lb.)	Weight of Radiator and Cooling Water (lb.)	Gross Weight (lb.)	Weight Empty with Water (lb.)	Fuel and Oil (lb.)	Military Load (lb.)	Crew (lb.)	Total Wing Area, incl. Ailerons (sq. ft.)	Wing Curve	Wing Loading (lb. per sq. ft.)	Power Loading (lb. per h.p.)	Performance: Speed (m.p.h.)	Performance: Level (ft.)	Performance: Climb (min.)
Glenn Martin	(Bl.)	3	2 Liberty-12-A	397 / 1700			9663	5862	1492	1700	540	1070		9	14.4	118.5	0 / 6500 / 10000	20' 45" / 22' 10"
Caproni Standard and Fisher	(Bl.)	4	3 Liberty-12	300 / 1600	800	510	12340	5700	2350	1800	715	1384		9.3	13	100	0 / 5000 / 10000 / 15000	0 / 14' 33" / 28' 40" / 46' 30"
Handley-Page Standard	O-400 (Bl.)		2 Liberty-12	397 / 1700	879	524	14300	7874	2500	3350	510	1648		9.5	12.0	96 / 90 / 86	0 / 5000 / 7000 / 10000	[illegible]

7.—Training Seaplanes (Pontoons)

Government Department or Manufacturer	Type	No. of Crew	No. and Make Engines	Horsepower at r.p.m.	Weight of Engine (lb.)	Weight of Radiator and Cooling Water (lb.)	Gross Weight (lb.)	Weight Empty with Water (lb.)	Fuel and Oil (lb.)	Military Load (lb.)	Crew (lb.)	Total Wing Area, incl. Ailerons (sq. ft.)	Wing Curve	Wing Loading (lb. per sq. ft.)	Power Loading (lb. per h.p.)	Performance: Speed (m.p.h.)	Performance: Level (ft.)	Performance: Climb (min.)
Curtiss	N-9 (Bl.)	2	1 Curtiss-OXX	100 / 1400	430		2410	1900	150		360	496	Eiff. 36	4.86	23.1	70	0 / 5000	0 / 10
Standard	JH (Bl.)	2	1 Hall-Scott-A-7a	100 / 1400	445	55	2350	1650	210		360	420	R.A.F. 3	5.2	26.2	67	0 / 5000	[illegible]
Curtiss	N-9H (Bl.)	2	1 Hispano-Suiza	150 / 1600	475	150	2610	2000	150		360	450	Eiff. 36	5.1	16.7	60	5 / 3000	[illegible]
Curtiss	R-6 (Bl.)	2	1 Curtiss-V2	200 / 1600			3650	2350	600		360	600	R.A.F. 6	5.9	18.0	86	0 / 600	[illegible]
Curtiss	F (Flying Boat) (Bl.)	2	1 Curtiss-OXX	100 / 1400	420		2155	1440	230	106	360	420		5	21	65	0 / 1000	[illegible]
Aero-Marine	M.L. (Bl.)	2	1 Hall-Scott-A-7a	100 / 1400	445	55	2050				230	430				77.0	0 / 2000 / 10,000	[illegible]

8.—Light Bomber Seaplane (Pontoons)

Government Department or Manufacturer	Type	No. of Crew	No. and Make Engines	Horsepower at r.p.m.	Weight of Engine (lb.)	Weight of Radiator and Cooling Water (lb.)	Gross Weight (lb.)	Weight Empty with Water (lb.)	Fuel and Oil (lb.)	Military Load (lb.)	Crew (lb.)	Total Wing Area, incl. Ailerons (sq. ft.)	Wing Curve	Wing Loading (lb. per sq. ft.)	Power Loading (lb. per h.p.)	Performance: Speed (m.p.h.)	Performance: Level (ft.)	Performance: Climb (min.)
Gallaudet	D-4 (Bl.)	2	1 Liberty-12	380 / 1600			4200	3010	650	485	350	312	R.A.F. 15	8.8	13.5	118	0 / 5000 / 5100	[illegible]

9.—Submarine Patrol and Convoy Machines (Flying Boats)

Government Department or Manufacturer	Type	No. of Crew	No. and Make Engines	Horsepower at r.p.m.	Weight of Engine (lb.)	Weight of Radiator and Cooling Water (lb.)	Gross Weight (lb.)	Weight Empty with Water (lb.)	Fuel and Oil (lb.)	Military Load (lb.)	Crew (lb.)	Total Wing Area, incl. Ailerons (sq. ft.)	Wing Curve	Wing Loading (lb. per sq. ft.)	Power Loading (lb. per h.p.)	Performance: Speed (m.p.h.)	Performance: Level (ft.)	Performance: Climb (min.)
Navy-Curtiss	NC-1		3 Liberty-12	400 / 1600	800		21000			7750		2380		9.1	21.7	58	0 / 1000	[illegible]
Navy	F-5L		2 Liberty-12	360 / 1800	800		13000			4750		1397		9.3	18.7	87	0 / 2500	[illegible]
Curtiss	H-16		2 Liberty-12	300 / 1600	850		10000			2500c		1164		8.4	16.0	90	0 / 2000	[illegible]
Navy-Curtiss	HS-2L	2	1 Liberty-12	300 / 1600	1221	197	6432	4040	600	670	600	800		8.1	18.4	91	0 / 2750	[illegible]

*Including area of non-skid planes (16 sq. ft.)

Type	Ceiling (ft.)	Span	Chord	Gap	Incidence of Wings (deg.)	Dihedral (deg.)	Sweepback (deg.)	Decalage	Stagger (deg.)	Length Overall (ft.)	Height Overall (ft.)	Area of Stabilizer (sq. ft.)	Area of Elevator (sq. ft.)	Total Aileron Area (sq. ft.)	Area of Fin (sq. ft.)	Area of Rudder (sq. ft.)	Total Vertical Area (sq. ft.)	Fuel Capacity (gal.)	Oil Capacity (gal.)	Landing Speed (m.p.h.)
G-2 (Bl.)	[illegible]	43' / 33' 4"		6'	1	1½	0		7½	29' 1	9' 0"	29.15	27.7	50.06	2.2	14	17.2	86	0	
U.S. B-1 (Bl.)	[illegible]	30' 4	5' 0"	5' 5"		3	0		18½	26.5	8' 3"	21.8	17	50.08	8.7	7	10.7	310		
C-II (Bl.)	[illegible]	41' 7"		5' 5"	1	0	0	0	35	25' 3"	6' 7"	17	30.4	64.4	3.4	13.1	16.0	400		
18-T (Tri.)		31' 11"	3' 5"	3' 0" / 2' 11"	0½	0	5	0	0	23' 3"	9' 10"	14.3	13	21.5	5.2	12	18.2	37		
(Mon.)	[illegible]	30' 4"	7'	0	2	1	0	5	0	23' 9"	6' 5"	14.0	10	24.0	5.8	8	17.8	54	8	50
DH 10-A (Bl.)	[illegible]	65' 0"	7	7	2	4½	2½	0	0	39' 9"	12' 11"	75.0	33	108.0	15	25.7	35.7	170	20	
Glenn Martin (Bl.)		71' 5"	7' 10"	6' 5"		0	0	0	0	46	14' 7"	62.3	45.2	155.0	17.0	33	60.5			
Caproni (Bl.)	[illegible]	76' 9"	9' 2"	9' 1"	6	0	0	0	5	41.5	14' 5"	77.7	61	300.0	0	50.5	62.5	500	50	
O-400 (Bl.)	[illegible]	100' / 70'	10'	11'	5	4	0	0	0	62' 10"	22	111.0	80	172.0	14.7	46	86.7	380	51	
N-9 (Bl.)		53' 4" / 43	5	5'	2	0	0	0	0.8	29' 10"	10' 10	62.7	58		3.8	12	16.5	20	4	46
JH (Bl.)		45' 10" / 30'	6'	5	0½	3	5	0	4½	35' 7"	10' 10"	60.7	60	54	3.7	10	13.7	31	3	45
N-9H (Bl.)		53' 4 / 43'	5	5	2	0	0	0	12	29' 10"	10' 10"						10.0	20	4	46
R-6 (Bl.)		68' 3" / 48' 2"	75	74"	2½	3	0	0	10.75	34	14	48.4	27.5		7.6	18.7	50.7	106	6	50
F (Flying Boat) (Bl.)		55' 2" / 46'	60"	71"	0½	0	5	0	0	25	9' 5"	38.5	27.2		26.2	15.5	37.7	34	4	
M.L. (Bl.)		37' 2 / 32' 3"	6' 3"	6' 5		1		−1	10	26' 11"	12' 4"	38	21			16.0		41	2	43
D-4 (Bl.)		46' 5"	7	7		0														
NC-1		126	15	12			0	0	0	68' 3"	24' 5"									61
F-5L		100' 9"	5					0	5	49' 4"	12' 8"									57
H-16		95	7' 1"					0	0	46' 2"	17' 0"									50
HS-2L		74' 1"	5' 5"	7' 7"	3½	2	0	0	0	38' 5"	14' 2"	55.8	55.8		10.5	26	61.6*	110	5	55

The Packard Aircraft Engines and Airplane

Aircraft engineers and manufacturers, who were intimately associated with aeronautical development during the war, generally agree that in spite of the wonderful progress which took place during that period, this was necessarily of a forced nature. While splendid results were thus obtained, a great deal of refinement of details still remain to be brought about rapidly under peace-time conditions, tending toward the simplification of the airplane—at the same time adding greatly to its reliability and safety

The Packard engineering and manufacturing organizations are well equipped to take up this peace-time development on account of their intimate participation in the Government's aircraft program as well as their exhaustive study of aircraft engine development during several years just before this country entered the war

Packard 160 Hp Engine

Since the Armistice was signed, the Packard Engineering Department has designed a series of aircraft engines based on their extensive experience with a view to covering the field of fixed-type cylinder aircraft engines In designing these engines, it has been aimed at to retain all the good features of the experimental Packard aircraft engines, developed before the war, which were incorporated in and proved out by the Liberty engine, and to eliminate the objectionable features—these largely having to do with installation difficulties. This has resulted in a handsome saving in weight in the completed plane, as well as in reducing the complication, increasing the reliability and improving accessibility of the engine

As the three engines in this series are of similar design, the following description of the smallest engine, model 1-A-744, aptly illustrates the entire line

Model 1-A 744 Engine

Number of Cylinders—Eight cylinders, $4\frac{1}{4}$ in bore by $5\frac{1}{4}$ in stroke—set at an included angle of 60-deg

Crankshaft—The crankshaft is of the 5-bearing type, all bearings being carefully proportioned to give uniform life

Connecting Rods—The connecting rods are of the straddle type, properly proportioned and equipped with proper bearings to give uniform, long and uninterrupted service

Pistons—The pistons are of the aluminum die-cast type, equipped with floating piston pin, and a new arrangement of rings to prevent fouling of plugs when coasting down from high altitude.

Propeller Hub—The propeller hub is of the quick detachable type, carefully designed to prevent freezing on the shaft or becoming loose

Crankcase—The crankcase is of the box-section type, split on the center line of the crankshaft with the main bearings carried between Long through-bolts unite the two halves

Cylinders—The cylinders are of the individual steel type, which gives beside lightness and reliability excellent water circulation and valve cooling

Valves—The valves are 2 in diameter in the clear with 30-deg seats—the intake valve lift being $\frac{7}{16}$ in and the exhaust $\frac{3}{8}$ in This generous valving results in a very high m.e.p. even at speeds of 1800 or 1900 r.p.m.

Camshaft and Rocker Arm—The camshaft and rocker arm assembly is of the enclosed type, developed by Packard before this country entered the war, and used on the Liberty engine with great success

Lubrication.—Lubrication is of the full pressure feed type. The oil pump, screen, and blow-off valve are located low down, which makes them easily accessible through suitable doors provided in the airplane body

Cooling System—The engine is designed especially for the use of a nose radiator but is equally adaptable to any other type of radiator arrangement The water pump, situated underneath the crankcase, is equipped with an automatic spring take-up for the stuffing box and is readily accessible from underneath the engine.

Ignition—The ignition is an improved Delco type in which the heads remain stationary and the spark advance is obtained by advancing the drive shaft. Complete double ignition to two sets of spark plugs is provided and the engine will function properly on either set The ignition distributor heads are easily accessible from each side of the airplane body The generator is located in the saddle of the engine and is quickly detachable for inspection

Carburetion—The carburetor is of the double Venturi type, with improved altitude adjustment It is located on the bottom of the crankcase, which in addition to making it very accessible, provides for proper gravity feed and keeps the intake passages properly warmed without recurring to the hot water jacketing system

Weight—The engine, complete with propeller hub, carburetor, ignition distributor heads, ignition switch, generator, starting motor and starting switch, weighs 520 lb. A proper battery to provide current for cranking and starting ignition weighs 40 lb The water contained in the cylinder jackets, pump and pipes weighs 25 lb A nose radiator to cool this

engine holds 27 lb of water, making the total weight of cooling water 52 lb A nose type tubular radiator weighs 73 lb

General Dimensions.—Center to center of bed timber bolts, $14\frac{1}{2}$ in , extreme width over-all, $27\frac{1}{2}$ in , highest point above bed timber, $20\frac{1}{2}$ in , necessary distance between radiator and front bulk head for proper mounting is 34 in. to 36 in

Model 1-A-1116 Engine

The specifications for this engine follow those for model 1-A 744 exactly, with the exception that it is provided with twelve cylinders, instead of eight, and is 12 in longer

Nose of the Packard Biplane

The weight of this engine, complete with propeller hub, carburetor, ignition distributor heads, ignition switch, generator, starting motor and starting switch, is 710 lb.

Model 1-A-2025 Engine

The design of this engine is exactly similar to model 1-A-1116, with the exception that the dimensions are changed as required for $5\frac{3}{4}$ in. bore by $6\frac{1}{2}$ in stroke

The weight of this engine, complete with propeller hub, carburetor, ignition distributor heads, ignition switch, generator, starting motor and starting switch, is 1,000 lb.

In spite of the fact that this is one of the largest aircraft engines designed to date, its compact arrangement makes a very neat streamline installation possible.

Packard Airplane

After laying down the design of their new series of aircraft engines, the Packard engineers turned their attention to the design of an airplane around the smallest model with the view of producing an airplane embodying the greatest number of valuable features made possible by this new engine.

In the design of this plane particular attention has been paid to the safety of the passengers as regards strength and reliability, the very best materials are therefore used in its construction and the factor of safety is over seven .

While designed for the man who appreciates utmost reliability in airplanes, this machine also answers the demands of those who want a light, maneuverable machine, capable of the very highest order of performance consistent with reasonable economy and comparatively slow landing speed

The following is a specification covering this plane

POWER PLANT

Packard 8-cyl., 160 hp. engine, 160 hp. at 1525 r.p.m.
Weight complete with propeller hub self-starter battery and engine water—555 lb
Fuel consumption .50 to .54 lb per hp at sea level

WING AND CONTROL SURFACE AREAS	
Main planes total	387.6 sq ft.
Ailerons, total	48.3 sq ft.
Vertical fin	7.8 sq ft.
Rudder	12.0 sq ft
Tail plane	35.7 sq ft
Elevator, total	21.9 sq ft.
WEIGHT	
Machine empty	1520 lb
Gasoline	210 lb
Oil	30 lb.
Water	52 lb
Tools and extras	25 lb
Pilot	165 lb.
Passenger	165 lb
Normal flying weight	2167 lb
Weight, lb per hp	13.5 lb
Wing loading per sq ft	5.8 lb.
Permissible extra luggage	100 lb
PERFORMANCE (Estimated)	
High speed near sea level	102 m.p.h.
High speed at 5,000 ft.	100.5 m.p.h.
High speed at 10,000 ft	98 m.p.h.
High speed at 15,000 ft	90.5 m.p.h.
Climb to 5,000 ft	7.0 min
Climb to 10,000 ft	18.1 min.
Climb to 15,000 ft	34.5 min.
Absolute ceiling	18,500 ft.
Fuel range, wide open, near sea level	2.5 hr
Fuel range, wide open, at 5,000 ft	3 hr
Fuel range, wide open, at 10,000 ft	3.3 hr
Fuel range, wide open, at 15,000 ft	4 hr

Packard Biplane, 160 Hp. Packard Engine

THE INSIDE STORY OF THE CURTISS

1. The new Curtiss Model K 12 aeronautical motor
2. A Curtiss J N in flight.
3. The Curtiss Flying Boat built for Rodman Wanamaker.
4. A Curtiss Mailplane.
5. The famous Curtiss J N 4D on which over 98% of all American and Canadian pilots were trained.
6. The Curtiss O X motor regarded by experts as the best 90 H P aeronautical motor made.
7. The Curtiss Model L Triplane.
8. A Curtiss Triplane Flying Boat.
9. Another view of the Curtiss K 12 motor — this motor is 25% lighter than any other 400 H P motor so far produced.
10. The familiar J N profile.
11. The Curtiss Engineering Corporation Plant at Garden City L I
12. The fuselage assembly floor
13. A recent commercial Curtiss Tractor
14. A Curtiss twin J N.
15. A rear view of the Curtiss H. S 2 flying boat.
16. A Curtiss Triplane military tractor
17. Three early Curtiss military tractors.
18. The mammoth navy N C 1 flying boat, built by the Curtiss Engineering Corp. recently flew with 51 persons aboard. The largest flying boat in the world.
19. A modern English type of military tractor
20. A Curtiss Triplane Hydro.
21-22. Building flying boat hulls for the navy.
23. A view on the assembly floor at one of the Buffalo plants.
24. Another one of the Buffalo assembly floors.
25. A panoramic photograph of the general assembly floor at one of the six Curtiss Buffalo plants
26. The motor assembly at Hammondsport.
27. A Curtiss F boat.
28. The Curtiss H S flying boat.
29. A few of the thousands of women employed in Curtiss plants.
30. Two Curtiss Triplanes.
31. Assembly floor—Fuselages.
32. A skeleton of the Curtiss J N showing construction.
33. The Curtiss R 4 Mailplane.
34. An aeroplane photo of the Buffalo North Elmwood plant just before completion.
35. Girls sewing wing panels.
36. The new Curtiss M. F flying boat
37. The fastest aeroplane in the world. The Curtiss type 18 credited in government reports with 163 miles per hour with full military load of 1100 pounds.
38. The most efficient Hydro in the world.
39. The first hull of the FSL flying boat.
40. The Curtiss J N 4 D
41. The Curtiss H 12 flying boat.
42-45. Various departments in the Buffalo plants of the Curtiss.
46. A general view of one of the Curtiss metal working shops.

SEE OUR EXHIBIT AT AERONAUTICAL EXPOSITION AT MADISON SQUARE GARDEN N Y MARCH 1st TO 15th.

CURTISS AEROPLANE & MOTOR CORPORATION, Sales Office: 52 Vanderbilt Avenue, New York City

Factories and Flying Fields: Buffalo Hammondsport, N. Y. Newport News, Va. Miami, Fla. CURTISS ENGINEERING CORP., Garden City, L. I. THE BURGESS CO., Marblehead, Mass.

In the event that the Packard Co. should decide to take up the manufacture and sale of this airplane, exhaustive sand tests under official supervision will be completed before any deliveries are made to customers and a copy of such sand test report will be furnished to each purchaser so he may be fully informed as to the exact strength of his machine.

On account of the arrangement of the carburetor, with its air intake protruding through the lower part of the fuselage, it is claimed that it is absolutely impossible to set this plane on fire under any condition.

The comfort of the passengers has been carefully looked after. The engine is entirely housed in, making it impossible for oil or gases to blow back in the passengers' faces and built beads are provided on each side of each passenger to prevent drafts.

The after cockpit is arranged especially for the pilot, but the necessary dual controls are provided, so it can be flown from the front seat, thus making it possible to use this machine for instruction work when desired. The controls in the forward compartment, however, can be removed quickly, if it is desired to make it impossible for the passenger to interfere.

The machine is provided with a compartment for clothing and another for two suitcases, which should be found very convenient for cross-country flights.

The Murray-Willat Valveless Rotary Engine

The Murray-Willat valveless rotary engine is of the two stroke type, with a pressure blower built as an integral part, which compresses the air and forces the fuel into the engine at altitudes where the rarefied atmosphere fails to perform this function.

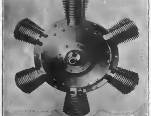


Fig. 1 Front View of the 90 Hp. Model

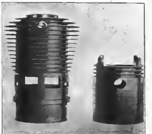


Fig. 2 Cylinder and Piston of the 90 Hp. Model

The first engine of this type was built by the Murray-Willat Co. in 1910, and after some experimentation two models were built, the characteristics of which are given herewith:

90 H.P. Model

Bore	130 mm
Stroke	130 mm
Engine speed	1,200 r.p.m.
Horsepower	90
Gasoline consumption	34 litres p.h.
Oil (mineral) consumption	10 litres p.h.
Maximum diameter	737 mm
Weight including airscrew hub	118 kg

35 H.P. Model

Bore	77 mm
Stroke	90 mm
Engine speed	1,200 r.p.m.
Horsepower	35
Gasoline	14 litres p.h.
Oil (mineral)	3 litres p.h.
Diameter	660 mm
Weight	60 kg

Fig. 1 shows the front part of the 90 hp. engine with open exhaust ports allowing for full scavenging and permitting a blast of fresh air to blow through the cylinder and across the top of the piston at the end of each stroke. As each cylinder fires every revolution, the torque is of the same character as that produced by a 12-cyl. four stroke engine.

The cylinders are turned from forged steel billets. The large ports (Fig. 2) are the exhaust ports, while the smaller ones are the intake ports, the latter register with the deflectors provided on each side of the top of the piston, throwing the incoming charge toward the top of the cylinder and preventing it from escaping through the exhaust ports until the piston on its upward course closes all the ports.

The crankcase consists of two halves, which are machined from solid steel forgings. Each cylinder is securely held in place by a shoulder which fits into a corresponding groove in the crankcase. With the cylinders assembled, the two halves of the crankcase are then bolted together, clamping the cylinders in with a positive grip, which dispenses with the necessity of using any cylinder bolts, clamps, grip rings, etc. The number of small parts is thus reduced to a minimum, and assembly and overhauling are greatly facilitated, the usual time employed in dismantling the engine being from 20 minutes to half an hour.

The connecting rods are mounted in a spool which is carried in a ball bearing on each end, the whole unit revolving with the engine, while the crankshaft remains stationary. The latter is hollowed out for the purpose of affording passage to the gas from the blower into the crankcase, where it is held under a pressure of 7 lb. furnished by the blower. This blower, which can be made of sufficient capacity to compensate for loss of pressure at high altitudes, is contained in a housing provided behind the rear plate of the crankcase; it is operated by a rotor and blades which turn with the crankcase.

Ignition is secured by means of a magneto which is mounted at the rear of the crankcase to the blower housing.

Liberty Aircraft Engine Ignition

By O. T. Kreusser

Engineer of Aviation Ignition Instruction, The Dayton Engineering Laboratories Co.

The reliability of all high powered aeronautical engines in flight is largely governed by the dependability of its spark plugs. The service, due to the extreme temperature and pressure conditions, is so severe that satisfactory performance can only be obtained by the use of duplicate spark plugs in each cylinder. This design requires the use of an ignition system so duplicated that independent operation can be obtained with either set. It also permits construction so the failure of any part of the ignition system will not cause interruption in the functioning of the whole system.

The Liberty engine having its cylinders located at an angle of 45 deg., has its explosion impulses at unequal intervals, or at periods of 45 and 75 deg. alternately, for the 12-cyl. model, and 45 and 135 deg. for the 8-cyl. model. To obtain an ignition spark of the same intensity at these irregular intervals, and the simultaneous occurrence of the duplicate sparks, not only at the proper firing angle, but maintain that relation at all speeds, calls for scientific design of apparatus and accuracy of manufacture of all the parts.

The Delco generator battery type of ignition having proven itself particularly adapted for reliable high speed work, is used as the means of operating all Liberty aircraft engines. The ignition, being designed and developed for this work, forms an integral part of the engine itself. Full advantage has been taken in the design to make its attachments simple and its timing accurate.

Advantage has been taken of the sturdy construction that this type of ignition permits, and parts are constructed to give, not only long life and wear, with few adjustments but reliability, insured by the duplication of parts performing the same function. In this way the factor of safety against mechanical failure of parts is generous, which together with light weight is of importance in aviation work. Accessibility, permitting the desirable ready inspection of parts and adjustments when in the airplane, as well as rapid testing before and after installation, is also a feature which has taken an important part in its design.

The Liberty ignition produces a spark of maximum intensity at low speed, insuring easy starting and regular idling. It operates equally as well at high speed, at all times producing a single intense spark at the instant required, reducing the wear and heat at the spark plugs to a minimum—a particular advantage over an ignition giving a shower of sparks or flame, causing excessive high tension distributor wear, and spark plug trouble. It further permits ready mechanical synchronism of the high tension current furnished to the duplicate system of spark plugs and is weather and moisture proof and unaffected by climatic conditions.

The generator battery ignition in use on the Liberty engines consists of a constant source of low voltage direct current, supplied by a generator and a storage battery. The generator is so arranged that the voltage is kept constant at all operating speeds. As the generator does not produce sufficient voltage at cranking or extreme low idling speeds, the current at this time is supplied by the battery. In this way a practically constant pressure of low voltage current is available at all times. The battery is of special construction, light in weight, and will function satisfactorily in any position without leaking electrolyte. The capacity of the battery without the generator in circuit, is sufficient to operate the Liberty-12 at flying speed for three hours with double ignition or even eight hours with single ignition. The engine after once being started can be operated indefinitely without the battery, provided a speed of over 500 r.p.m. is maintained. In normal operation the battery provides the current for starting and for all engine speeds below 650 r.p.m. by using single ignition. Above speeds of 650 r.p.m. double ignition is used at which time the generator is automatically placed in the circuit and supplies the current for the ignition and keeps the battery charged. The battery remains in circuit at all times, as an emergency source of supply in event of damage to the generator or its circuit. As battery current must be available to permit starting the engine it assures an available emergency supply at all times when operating.

Fig. 1. Parts Making Up Ignition Generator

The low voltage current supplied by the battery or generator is controlled by means of a two-lever switch unit containing an ammeter which at all times indicates the flow of current to or from the battery. The switch is usually located on the cowl, convenient to the pilot.

Through the switch the current is supplied to the two distributors which are mounted horizontally and form the ends of the overhead camshaft housings. The right hand switch lever controls the current to the right hand distributor which furnishes the high tension current to each spark plug at the distributor side of each cylinder. The left hand switch lever controls the current to the left hand distributor which furnishes the high tension current to each cylinder at its propeller end plug.

The distributors which are identical and interchangeable are constructed with an ignition coil, which provides the means of transforming the low voltage current to high voltage, and a breaker mechanism. The breaker mechanism interrupts the low voltage current supplied from the switch after passing through the primary winding of the ignition coil and causes high voltage current to be produced in the secondary winding of the coil.

The coil is sealed moisture proof in a Bakelite moulded head which forms the cover enclosing the breaker mechanism. The electrical connections between the coil and breaker mechanism

are made by installing and securing the Bakelite head in position

The high tension current generated in the secondary winding of the coil is delivered to a high tension rotor fastened to the cam actuating the breaker mechanism contact arms, and distributes the high tension current to the spark plug lead terminals which are located around the periphery of the Bakelite head at proper angular position

The spark plug lead from each terminal is carried through

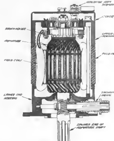


Fig 2 Liberty Ignition Generator in Cross Section

a high tension manifold consisting of a drawnlight steel tube This is used to avoid trouble caused by induction and is secured on top of the engine with an outlet for each lead over its particular spark plug.

As each distributor supplies each cylinder with ignition and is independently operated by the respective engine cam shaft continuous operation of the ignition is assured in event of breakdown of either.

Advance and retard is obtained by revolving the distributor breaker mechanism and head on its base. A retard of 10 deg and an advance of 30 deg is provided Simultaneous movement of both distributors is obtained by connecting them together with a straight adjustable connecting rod giving a simply accurate control. As the ignition units were designed to form an integral part of the engine, the attachment is made simple and substantial, and timing positive and accurate

The distributors are constructed so the drive pin and high tension rotor bear a definite relation to the distributor cam lobes which operate the breaker contact arms. In this way the positive relation between interruption of the primary current and the distribution of the secondary cannot be varied The driving flange which engages the drive pin is uniformly located on the engine cam shaft, so when the engine crankshaft is brought to any firing point the ignition distributor can only be applied in correct relation

The accurate timing of the ignition to the engine is most easily accomplished by setting No 1 left hand piston to full retard position, i. e. 10 deg past top dead center on firing stroke This position brings the driving slot of the distributor drive flange fastened to each cam shaft in the center line of its respective cylinder block, with slots pointed upward. With distributor revolved to full retard position it is directly fastened to the cam shaft housing which is flanged to accommodate same As the drive pin must first engage the driving slot to permit the base to seat, the distributor rotor locates itself at a position directly in the center of the spark plug terminal for No 1 left hand cylinder This is the same on each distributor To care for the possible variation of machine work upon cam shaft and housings and distributors, the fastening holes in the distributor base are slotted This permits of slightly varying the opening of the breaker points in relation to piston position and obtaining accurate mechanical synchronization of one distributor with the other

Both distributors are set independently without changing position of the crankshaft and secured so the contacts are just beginning to separate with proper rotation of cam An accurate means of checking synchronization is accomplished by using two low voltage lamps and a battery and connecting one lamp in series with each breaker mechanism The simultaneous opening of the contact points is indicated by the simultaneous flashing out of the lights

Ammeter

The use of an ammeter permanently located in the primary circuit gives a very rapid method of checking the condition of the entire low voltage circuits. This can be done with engine stopped or operating When cranking an engine for starting with one switch lever placed in "on" position, the ammeter shows a 4½ to 5 amperes discharge, abruptly dropping to zero as the contact points open When the engine operates at low idling speed on single ignition the ammeter shows 3 amperes discharge which decreases to 1½ amperes at high speed Each ignition is tested separately by idling and accelerating on each switch alone, which checks one distributor circuit against the other At 650 r p m. with both switches in "on" position the ammeter reads zero or charge, as at this speed the current for ignition is furnished direct by the generator, and any excess flows to the battery Upon accelerating with both switches "on" the ammeter should show charge If the charge is excessive, i e over 5 amperes, it most likely indicates a battery that has been excessively discharged

By means of the ammeter, not only proper ignition performance, but improper functioning, even though the engine may be running regularly, is immediately indicated and can be rapidly isolated By means of the ammeter, defects can be located without loss of time or disturbing connections or units

The ammeter thus provides the pilot or operator with a visible means of knowing that ignition is functioning properly, as well as usually informing him of improper functioning long before it is indicated to the operation of the engine

Generator

The generator is a four pole shunt wound unit of compact design and the rugged construction which low voltage direct current machines permit It is approximately 6½ in. high and 4⅛ in in diameter and weighs 11.25 lb It is mounted vertically directly upon the engine on top of the crankcase at the distributor end, in the 45 deg angle V between the cylinders The armature shaft extends into the crankcase where it is driven by the generator driving assembly which forms the driving unit, actuating the vertical drive for the engine overhead camshafts The generator is driven at one and one half times crankshaft speed by means of the armature shaft which is splined, engaging the socket of the driving assembly forming a simple positive drive with the engine

The generator is made up with a forged steel field frame and provided with four forged pole pieces securely held in place by two shoulder tap screws each. The field coils are wound and connected together and properly shaped and impregnated in insulating varnish and rigidly held in place by the pole pieces

The generator field frame is fitted with upper and lower end housing of machined cast aluminum, all being secured together by means of four through tap bolts

The lower end housing is flanged and forms the pedestal for mounting the generator on the engine by means of three stud bolts It also contains a small countershaft containing a twelve-tooth spiral gear which is driven by a four-thread worm milled in the armature shaft, and forms the drive for the flexible shaft of the tachometer indicating the r p m of the engine.

The upper housing contains the ball bearing upon which the armature is pivoted The generator contains but a single bearing, the lower bearing being formed by the generator driving assembly with which the generator is accurately lined up by means of a turned pilot on the lower end housing

The upper housing also contains the four brushes (i e. two positive, which are insulated, and two negative which are grounded direct to the frame) These form the means of collecting the current generated. The use of four brushes which are of carbon, insures not only long life of brushes and commutator with little attention, but a factor of safety in event of brush or spring breakage The upper housing also contains the terminals forming the connections to the external circuit, and which are extended through a pressed aluminum cover encasing the upper housing of the generator, making same moisture and dust proof

One of the positive brushholder pivots is extended through the upper housing and cover and forms the positive generator armature terminal

The shunt field obtains its current by being directly connected to the armature circuit in the generator

The ground side of the field is carried out at the upper housing by means of an insulated terminal screw which extends through the aluminum cover, from which it is insulated by means of bushings secured with metal eyelets. The generator field is grounded through a connection made from this terminal to the voltage regulator The generator voltage is controlled by the current flowing through the field which is automatically governed by the regulator

The armature is constructed with a built up core of punched soft iron laminations, which are firmly secured to the armature shaft The armature, which has twenty-one slots, is of the wave wound type with formed coils well insulated and secured in the core slots, and held in position by banding wires The commutator is built up of hard rolled copper and contains twenty-one segments with mica insulation The segments are slotted for driving fit of the coil leads which are soldered into position The commutator is machined to proper size, and the insulation between segments slotted one thirty-second inch below surface of bars. This is done to insure good commutation which would otherwise be hard to maintain, due to the uneven wear of copper and mica, which would cause brushes to chatter and result in burning and blistering of the commutator After the armature is completely assembled, it is impregnated with heat resisting insulating varnish and baked Its outside diameter is then ground to insure absolute concentricity and proper clearance with the pole pieces The armature shaft is of generous dimensions, and is bored hollow for the greater part of its length to reduce weight which insures minimum bearing strains The upper end of the armature shaft adjacent to the commutator is ground to accurately fit the ball bearing through which it extends, and is threaded and secured by washer and nut and cottered, which thus suspends the armature on the upper bearing, which is fastened in the upper housing

The voltage of the current furnished by the generator is governed by a voltage regulator so it never exceeds 10 to 10½ volts. Its current output is governed by the battery condition and load, but the generator is arranged to carry 5 to 6 ampere load continuously without excessive heating

Voltage Regulator

As the generator is supplying the current direct to the ignition in regular operation, it is essential that the pressure of the current supplied shall not vary materially from low to high speed It is by means of the voltage regulator that the pressure is kept practically constant at operating speeds, regardless of the variation in engine speed. The voltage regulator is mounted in a cast aluminum cup, usually on the back of the dash directly behind the switch, being secured with the same bolts holding the switch It functions very reliably and in actual service gives no trouble and requires practically no attention

The regulator is an automatic device, controlling the amount of current flowing through the generator field circuit Reducing or increasing the amount of current flowing through the field coils reduces or increases the amount of magnetic flux, with a corresponding decrease or increase in the voltage produced by the armature

In design the voltage regulator consists of a soft iron core over which is mounted a pivoted iron armature, normally held away from the core by an adjustable coil spring in tension Mounted on this armature is an adjustable tungsten contact point in circuit when closed, with a stationary contact and forming a generator field connection to ground of low resistance. Around the core are wound three windings, which control the opening and closing of the contacts and the current in the generator field circuit.

The voltage generated in the generator armature is impressed upon a voltage winding, and as the speed of the armature or the strength of the generator field increases, the amount of current flowing through this winding increases, producing

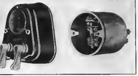


Fig 3 Liberty Switch and Voltage Regulator

an increasing amount of magnetism in the core, and attracting the pivoted armature which causes the contacts to open. This immediately reduces the current flowing in the generator field to the amount limited by the flow through the other two windings, causing a weakening of the generator field and a corresponding control of voltage The decrease in magnetic attraction of the voltage coil permits the spring to again close the contacts, and establish a low resistance field path to ground. This action is repeated very rapidly, causing the contacts to continually vibrate at high speed, increasing as the speed of the generator armature increases

The regulator is adjusted by changes of spring tension. Increasing the tension increases the voltage produced by the generator, and vice-versa

Switch

The switch is located on the dash within convenient reach of the pilot. It is composed of a black moulded Bakelite base containing all the contacts and connections.

The circuits are controlled by means of two aluminum switch levers operating spring bronze contact fingers which make connections with the contacts moulded in the base. The left hand lever operating from vertical to the left completes the circuit to the left hand distributor, and the right hand lever operating from vertical to the right completes the circuit to the right hand distributor When both levers are in "on" position the circuit from the generator is automatically completed The contacts and fingers are enclosed by an enamelled pressed metal cover forming the front of the switch. The cover contains the ammeter which is permanently connected in circuit by strap connections securely fastened in position

The switch contains two resistance units mounted upon porcelain spools, each one in series with its distributor circuit The resistance unit prevents an excessive flow of current through the distributor coil in event of switch being accidentally left in "on" position with engine idle

The external connections made through the bottom of the switch are four in number, located on a Bakelite plate with proper markings, viz., POS BAT, GEN ARM, R H DIST, and L H DIST

Distributors

To supply the duplicate ignition required, two 12-, or 8-cyl. distributors are provided, each one furnishing one of the plugs in each cylinder with an ignition spark at the proper time. Each distributor weighs 5.5 lb and is 7¾ in. overall diameter and 5⅛ in. high. The two distributors are identical and are interchangeable. They are identified as right hand or left hand according to their location on the engines and the posi-

tion of the advance lever, which is reversible. They are mounted, one on each of the two overhead cam shafts, fastening direct to the camshaft housing.

The ignition coil, which is contained in the distributor head, is a device which by means of induction low voltage current is transformed to high voltage current. It consists of a primary winding of a comparatively few turns of fairly heavy insulated copper wire, through which the low voltage current

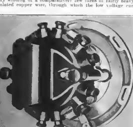


FIG 4 LIBERTY IGNITION DISTRIBUTOR

flows, wound around and insulated from a soft iron core, composed of a bundle of straight iron wires. The current flowing around the core produces a strong magnetic field. Another winding composed of thousands of turns of very fine copper wire is wound over, but insulated from the primary and terminates in ground on one end and a high tension carbon button at the other end. When the current flowing in the primary is interrupted abruptly by means of a breaker mechanism, a high voltage current is induced in the secondary winding due to the rapid change in the magnetic field.

The ignition coil is constructed and insulated to withstand the high voltage pressure induced, and is sealed moisture proof in the Bakelite head which forms the cover for the breaker mechanism to make same moisture proof. The terminals to the coil are carried outside the head by means of permanent straps and thumb nuts which connect up direct without leads with the breaker mechanism circuit. The head in addition is secured by spring clamps. The distributor head also incorporates the high tension distributing terminals to each cylinder and the high tension rotor track containing the terminal contacts located at the proper degrees apart to which the spark plug leads are connected.

The high tension terminal of the coil is a carbon button, extending through the under side of the head, and when in position on the breaker mechanism, makes contact with a flat spring on the high tension rotor.

The rotor carries a soft carbon brush which bears upon a hard rubber track, moulded integrally in the Bakelite head. The high tension terminals are spaced at proper angular relation around the periphery of the distributor head rim, the terminals being moulded in the hard rubber track and Bakelite head. Each terminal stud is properly marked with its cylinder number, and the spark plug leads are secured with lock washer and Bakelite thumb nuts at the terminal which are moulded into pockets uniformly locating each lead. The location of the ignition coil in the distributor head directly upon the breaker mechanism eliminates all high tension leads between the coil and high tension distributor.

The primary winding receives its current direct from the switch, an insulated lead being connected from the respective switch contact to the right hand side of each distributor. The connection at the distributor is made through one of the studs locating the head, thus avoiding disconnecting leads in removing head from distributor. The current after passing through the primary winding, continues to the breaker mechanism which completes the circuit to ground. Both the battery and generator have their negative side grounded using the engine frame as negative side of the circuit.

The breaker mechanism consists of contacts operated by a cam, which open and close the circuit between the primary winding and ground.

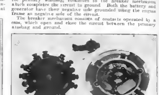


FIG 5. IGNITION DISTRIBUTOR, WITH HEAD AND HIGH TENSION ROTOR REMOVED

Two of the contact arms, located diametrically opposite each other and called the main contacts, interrupt the primary current producing ignition. Either contact alone is of sufficient capacity to indefinitely carry on operation. They are duplicated to insure safety in event of spring or contact point breakage. The duplication also affects chattering of contacts which cannot be entirely prevented at high speed. To further reduce chattering the main contact springs are cushioned with soft rubber blocks vulcanized to the contact arm. The arms are mounted on a bracket so pivoted as to provide adjustment for simultaneous operation.

A third contact arm called the auxiliary arm is electrically in parallel with the main arms but also in series with a resistance unit which limits the flow of current to this arm. This forms a safety feature preventing the engine from operating in a reverse direction.

In normal rotation (clockwise view from distributor end) the auxiliary arm contacts open a few degrees prior to the main contacts and causes no change in the amount of current flowing through the ignition coil. The main contacts opening the circuit and interrupting the flow of current abruptly, causes high voltage current to be induced in the coil.

Should the airscrew be turned in reverse direction the main contacts open first, leaving the auxiliary contacts closed, causing a reduction in the current flowing through the primary winding to an amount limited by the resistance unit in series with the auxiliary contact arm. This limits the current to such an extent that when the auxiliary contact does open the energy in the coil is so reduced that the spark obtained from the secondary is so weak that it will not produce ignition. The auxiliary contact being closed when the main contacts open also forms a short circuit for the condenser and prevents the induction of high voltage current.

The contact points are of tungsten metal, which gives long life on account of its extreme hardness, and does not readily burn and pit due to its high melting point. The adjustment of the contact points is obtained by thread and lock nut, all contact gaps are adjusted between .010 in and .015 in. The ignition will function efficiently at all speeds up to 2200 r.p.m. of the engine. This means 13,200 separate ignition sparks must be generated and distributed to the proper cylinder and at proper periods of 45 deg and 75 deg for the twelve cylinder engine each minute. A spring pressure of 26 to 30 oz on the main contact arms is provided.

The normal maximum operation of the 12-cyl engine in service is 1750 r.p.m.

The contact arms are actuated by means of a hardened and polished steel cam operated direct through a slot and eccentric pin coupling by the engine camshaft. As the camshaft operates at one half engine speed the cam is provided with twelve lobes for the 12-cyl. model, and eight lobes for the 8-cyl. model. The lobes are spaced at one-half the firing angle or 22½ and 37½ deg apart on the twelve lobe cam, and 22½ and 67½ apart on the eight lobe cam.

The contact arms are provided with selected horn fibre rubbing blocks which bear upon the cam, which causes contacts to open, overcoming the spring tension endeavoring to keep them closed.

By operating the breaker mechanism at one-half engine speed, long life of parts is obtained as well as the direct distribution of the high tension current to its proper cylinder without the use of intermediate gearing.

To produce an ignition spark of the same intensity at the unequal intervals as required by the Liberty, the valleys of the cam are so shaped that the contacts are closed for the same interval for all impulses. This is determined by the period between the narrow angle of fire which is 22½ deg on the cam. As the contacts must also open and close during this interval the actual period during which they are closed is 13 to 15 degrees. To provide for the long angle between firing points, the cam is shaped so the contacts remain open for an interval equal to the difference in angle between the short and long periods of explosion, thus making every alternate lobe on the cam wide. The cam is constructed hollow and packed with felt soaked with oil. A hole is provided into the cam through the high tension rotor to add lubricant while in service. The periphery of the cam upon which the rubbing blocks of the contact arms bear is provided with several small holes. The centrifugal action of rotation causes oil to pass out of these small holes and lubricate the surface of the cam. A small quantity of vaseline is added to the cam face at intervals to assist in maintaining the polished surface of the cam.

The condenser is used to reduce the arking at the contact points permitting them to interrupt the primary circuit rapidly which is necessary to produce the high voltage current required for ignition. It is made part of the bracket upon which the contact arms pivot.

The condenser is made up of two long strips of tinfoil, called the plates, insulated from each other by several thicknesses of insulating paper, called the dielectric. The condenser is connected in parallel with the contact points. One of the plates is directly connected by soldering to the metal case which contains the condenser, thus grounding same, and the other plate is connected by means of an insulated lead to the positive side of the contact points.

The condenser on the Liberty equipment is made up of two units in parallel sealed moisture and oil proof in a metal case.

Battery

The Liberty battery is of special design for operation in connection with the Liberty ignition and is small, compact, and of light weight, and designed to permit operation in any position without spilling or leaking acid. It is built in two types —the Willard, supplied by The Willard Storage Battery Co of Cleveland, and the Exide, furnished by The Electric Storage Battery Co of Philadelphia. In general design, capacity, and size they are the same. They differ slightly as to detail construction.

The current from the battery is used for ignition purposes only, for operating single ignition, slow speed and emergency running in event of damaged generator. It is 7 in high by 4 in deep by 5½ in wide and weighs, ready for service, 10¾ lb.

The battery is made up of a four compartment rubber jar which forms four cells. Each cell contains elements composed of three positive plates and four negative plates, which are burned to connecting straps and separated by separators of standard design.

The plates, which have a 3 x 3 in surface each side, extend about half way the total height of the jar, the bottom of the jar having supporting ribs ⅜ in high to form sediment pockets. The plates are sealed in the lower part of each cell by means of a hard rubber baffle plate, located directly on top of plates. The upper part of each cell is sealed by means of rectangular moulded hard rubber cap, which is secured in place with compound. Lead posts, burned to the element connecting straps, extend through the baffle plate, through the upper compartment, and out of the top of cell. They are sealed with rubber gaskets and nuts, or burned to lead bushings moulded in the cap, and form the cell connections or terminals.

The upper chamber is provided to permit the electrolyte to flow out of the lower plate compartment by way of two small holes in the baffle, when the battery is turned upside down. Its cubical contents are such as to permit holding all the electrolyte without same running out of the vent plug. This is screwed into the cap forming the top of the cell, and is of such length and so located that, when the cell contains the proper quantity

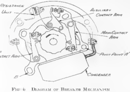


FIG 6 DIAGRAM OF BREAKER MECHANISM

of liquid, it can never reach the end of the vent plug and run out.

When the battery is in normal upright position, the electrolyte completely fills the entire lower compartment containing the plates and extends to the baffle plate, forming the bottom of the upper compartment.

The cells are connected in series by the adjacent terminal pillars having lead connecting links burned in position. The battery terminals are of the clamping type, made of brass, lead plated, with bored holes into which the lead is soldered. Clamping the terminal onto battery post is obtained by a slotted head machine screw, drawing clamp tight. The positive terminal, which is ⅜ in in diameter, is larger than the negative, which is ⁵⁄₁₆ in in diameter, to insure against accidental reversal of leads when connecting, which would cause ammeter to read incorrectly.

The battery jar is recessed to locate a strap to securely hold same in proper position in airplane. The battery is sometimes secured in a wooden container which is permanently fastened to the plane.

Wiring

The wiring as far as possible is carried in flexible aluminum conduit. The recommended low voltage wiring for lengths up to ten feet consists of Kerite No 14 cable with nineteen strands No 26 tinned copper wire insulated to a diameter of four mm (11/64 in).

The high tension manifold carrying the spark plug leads is made up and tested complete at the bench, each lead passing through a bakelite plate which designates each cylinder. The standard high tension wire is Kerite No 14 cable of nineteen strands of No 26 tinned copper wire insulated to a diameter of seven mm (9/32 in).

Vibrating Starter

It is sometimes desirable to start Liberty engines from the pilot's position, which is very advantageous on planes with several engines or permits the pilot to get started without assistance. A simple push button vibrating contact breaker may be located convenient to the pilot and connected in series with the left hand stud locating the Bakelite head upon either distributor and ground. Turning the engine over with switches "off" to draw a charge into the cylinders and then placing propeller so as to leave one piston in a firing position causes the ignition distributor contacts to be open. This is indicated by a zero reading on the ammeter when switch lever controlling circuit to distributor to which vibrator is connected is thrown in "on" position. By placing switch in "on" position and pressing vibrator push button, a shower of sparks is obtained in the cylinder in firing position causing the engine to start.

Douglas Automatic Airplane Ignition Interrupter

This instrument, designed to increase the safety factor in flying, is a product of the Great War. It is unique in its particular field and in its functioning is said to have met every requirement.

The interrupter is an invention of Theodore Douglas, president of The Duplex Engine Governor Co., Inc., of Brooklyn, N. Y., and was developed by him under the auspices of the National Advisory Committee for Aeronautics. Facilities for the development were furnished by the Navy and Army at various air stations.

The function of the instrument is to automatically inter-

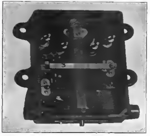


Fig. 1

rupt the engine ignition, thereby stopping the power development of the engine, in the event of the propeller breaking, or other similar breakage resulting in a seriously unbalanced condition of the power plant.

In flying, under other than war conditions, the risk of such breakages is fortunately not serious, though it is always present, and with certain types of machines the danger is greater than with others. Under war conditions on the other hand, such breakages, accidental or from gun-fire, are very frequent and in a large percentage of cases end fatally for the pilot.

The tendency of a tractor plane, in the event of its propeller breaking, is to go into a dive, and of a pusher plane to go into a stall. Under such conditions either type of machine is apt to pass into a spin as a result of the unbroken propeller blade tending to swing the machine around a neutral, or pivot, point between the center of pressure of the unbroken blade and the center of torque. Other factors may increase or lessen this influence, and the engine may or may not go overboard as a result of the unbalanced torque reaction.

The resulting intense vibration is apt to break a gasoline line, and, consequent upon the continuance of the flame of combustion exhausting into the gasoline-charged atmosphere, be followed by fire. Sometimes the most perfect mental and physical co-ordination on the part of the pilot fails to prevent this, since the brain and hand can seldom act quickly enough, as many thoroughly understood accidents of this nature attest. This manual limitation will be better realized when we consider that the time interval per revolution for airplane engines, assuming full throttle, varies from one twenty-third to one twenty-seventh of a second. Even under peace conditions some of our best pilots have been unable to prevent fatal crashes following such mishaps. This is particularly true at the present time with the high powered engines, high engine speeds, four bladed propellers, and the generally high stresses employed.

The interrupter supplements the action of the pilot in such instances, and through practically instantaneous action interrupts the power development, thereby confining the danger to the initial breakage. Such a breakage is seldom serious in itself. The danger lies in the unbalanced power development which follows, and the consequent injuries to the plane may range from a weakening of the general structure without show-

Fig. 2

ing visible fracture, through broken bearers, crankcase, crankshaft, gasoline line, etc., to a fatal crash. How important, then, it is to localize the danger through limiting the breakage to the initial incident—the propeller. The monetary cost and danger from such accidents would not be great if the danger stopped with the propeller. It is the consequent breakages which count, and particularly the overstraining of the general structure.

The interrupter is thought to be particularly desirable on twin engine machines, as such an accident happening to one engine would cause the good engine to tend to suddenly swing the machine around and probably into a spin. On such machines the interrupter may be so installed as to instantly cut out both engines, thus maintaining an approximately normal flying position. The pilot then has the alternative of making a landing with dead engines, or of switching off his damaged engine and continuing his flying with his good engine and reduced speed.

In the equipment of "blimps" the instrument would find another important application as it would tend to reduce the fire risk following propeller breakages, as the propeller fragments are apt to puncture the gas bag.

Features of Design

As to the elements of the design of the instrument, these are extremely simple and may be briefly described as consisting of a suitably pivoted metal bar, so mounted as to swing in a plane transverse to the axis rotation of the propeller. By means of tension springs 2-2 (Fig. 1), the free movement of this bar is confined, under normal airplane operating conditions, to a very limited arc in its plane of movement. The amplitude of this movement is determined by the weight of the bar, the intensity and frequency of the transverse vibrations of the engine, and the opposing strength of the springs confining it. The extended end of the trigger 3 is constantly pressed towards the floor of the instrument by the compression spring 4, and is designed to engage the latch 5. On the under side of the trigger 3 there is an inclined surface 6, by which the trigger is raised. A ball-pointed hardened steel screw is fitted into the bar directly beneath the trigger, and designed to engage an inclined surface and thus to lift the trigger when the swing of the bar is sufficient. When the trigger is lifted the latch 5, held under tension by the spring 7, is released and

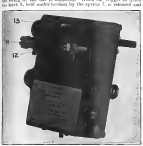


Fig. 3

moves out of engagement with the trigger. The cam 8 is for the resetting of the latch through rotating it back into position by means of the push button 10 from the outside of the instrument (Fig. 2).

The compression spring 9, presenting an unbalanced force, is designed to prevent the bar from disengaging the latch 5 as a result of cylinder misses coinciding with bad vibration periods of the engine, etc., thus increasing the amplitude of the swing of the bar through synchronism, or from lateral shocks to which the plane may be subjected in landing. An intense oscillating shock transverse to the axis of the engine, such as an unbalanced engine-propeller torque reaction resulting from the breaking of a propeller at speed, are the types of shock from which the instrument is designed to operate, and to which it will immediately respond. Under such conditions the bar will swing through its full amplitude, raise the trigger, which releases the latch, and thus interrupt the ignition through grounding the magnetos. From the interrupter terminals 11 and 12 (Fig. 3) wires are connected to the grounding terminals of the magnetos, and from the terminal 13 of the interrupter a wire is connected to the engine ground. On the disengagement of the latch 5 a triple contact is made between the interrupter terminals 11, 12 and 13.

Provision is made for testing, by the pilot before each flight, of the operation of the interrupter. Such a test can be conducted in ten seconds. The handle 14 (Fig. 2) which projects through a slot in the end of the instruments is pushed gently to the left until the red spot 15 of the tell-tale which bears a luminous cross for night flying, appears. Before the engine stops the instrument may be re-set by pressing down on the button 10 until the red spot of the tell tale disappears. Should the engine not stop it would indicate that either the interrupter switch is in the wrong position, or that its wiring system, etc., is defective.

A manually operated switch is provided with each instrument by which the interrupter may be thrown into and out of the grounding circuit as desired.

Types of Interrupters

Interrupters are furnished of two general types, maker and breaker instruments, and in several models to best suit various engines and airplane conditions.

Maker-instruments, such as the one just described, are intended for magneto ignition engines, in which cases there is no flow of current through the instrument, excepting at the moment of interrupting the ignition.

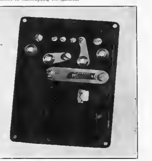


Fig. 4

Breaker-instruments are intended for Liberty engines, using the Delco battery ignition system, where the flow of the current is constantly through the instrument, and where two separate current channels are provided, because of the double distributor system used on these engines. The interruption of the ignition results from breaking these channels.

Different Models

The interrupter is manufactured in five models suiting it to the two general ignition systems employed—magneto and Liberty—and to the requirements of engine location whether on the body or in the wings. All instruments are provided with shunting switches. When the engine is located in the wings, the interrupter is mounted on a weather-proof casing attached to an engine-bearer, and the shunting switch is located on the instrument board.

The weight of the instrument, of both types and of all models, is under 10 oz.

Efficiency

The point has been raised that the presence of the instrument would be apt to complicate the ignition, and particularly so on the Liberty engine. Theoretically this would seem to be so, yet practically, judging from statements of naval pilots who have been flying interrupter-equipped machines during the past six months, experience would indicate that this possibility need not be seriously considered, as during that entire period the ignition of these Liberty engines has at no time been adversely affected. The operation of the instrument has been most satisfactory in every way, and has fully met all of the claims which have been made for it.

The various tests of the interrupter made by the Navy Department have shown in general the following results

(a)—As nearly as it has been possible to determine, the instrument will operate within one complete revolution of the engine following the propeller breakage, or within a time interval of one twenty-third of a second

(b)—It may be depended upon to do this every time that such a breakage occurs, as shown by tests in the air and on the ground.

(c)—It will not interfere with the efficiency of the ignition system nor has it caused complications thereof of any kind

(d)—The electrical resistance of the interrupter on Liberty engines has been determined by a representative of the Delco Co as being less than .03 to .05 ohm, representing a loss of potential in the primary current to the distributors of .33 to .55 of one per cent, a value which is entirely negligible

The design, workmanship, and materials employed in the construction of the interrupter are of high quality. The latches and triggers of the instruments are of hardened steel, heavily silver plated to minimize electrical resistance, to provide better contacts, and to prevent corrosion. Other contact parts are of hard brass, silver or nickel plated. All of the springs employed are of phosphor bronze. The electrical connections between the instrument base and its cover are by means of substantial screws which act not only as binding posts, but as attachment members holding the cover in place. These are all protected by castelled nuts and cotter pins. Dielectric parts consist of bakelite castings. Owing to the extended development and tests involved the instrument did not get into quantity production until Dec., 1918.

While by no means the most frequent cause of fatal accidents, the danger of fire in the air, or after a crash, is without doubt the most feared by pilots and passengers alike as it is the most difficult danger to guard against. Any instrument tending to lessen this hazard is therefore of decided value and will accomplish much toward increasing confidence in the safety of aerial navigation, which must mean better morale among pilots, observers, gunners, etc., and for the ordinary passenger a greater feeling of safety and security

The success of the commercial airplane will depend in a large measure upon engineering skill to minimize danger, and upon the ability of aerial passenger companies to convince the public that a trip in the air is free from any extraordinary risk

Two Notable Airship Voyages

In view of sundry information which has recently been forthcoming from abroad to the effect that the British rigid airship R33 is shortly to attempt to cross the Atlantic from England to America, considerable interest attaches to two remarkable airship performances which were made during the war and had, for this reason, been kept secret thus far.

The more notable of these performances consisted of a non-stop trip of about 4,500 English miles which the German naval Zeppelin L59 made in the fall of 1917 for the purpose of conveying from Bulgaria all sorts of supplies to the German forces which were holding out against the Allies in East Africa. This airship travelled as far as Khartum, Sudan, but turned back on wireless orders from the German Admiralty, the force it was intended to succor having surrendered in the meantime.

The other airship voyage, while of much shorter duration, is nevertheless remarkable because it indicates the possibilities of medium size, semi-rigid airships. This was made by an Italian Forlanini airship, with a British crew from Rome to the East Coast of England.

The 4,500-mile non-stop voyage of the Zeppelin L59 is described by one of the participants in the German aeronautical weekly *Luftpost* as follows.

From Bulgaria to East Africa and Back

"We left Jamboli, Bulgaria, at 8 35 a. m., on Nov 21, 1917. One hour later we reached Adrianople, and by 6 o'clock in the evening we had already passed Smyrna, while at 8 p. m. the channel of Lipsos was sighted. During the night we crossed the Mediterranean Sea and left it behind us at Ras Bulas the next morning at quarter past five, whence we directed our course towards our destination via the Lybian desert.

"We had thus succeeded in crossing within 17½ hours three continents—Europe, Asia, and Africa—a performance which heavier than air craft will be able to duplicate only if aviation develops a great deal further. The inhabitants of the oasis Farafrah, which place we passed at half past twelve, will long remember the aerial ghost that had come to them, and, at any rate, will keep the empty tin boxes we dropped thereabouts as a lasting souvenir of the rare event. While heading for the oasis Dakhel, which we reached at 3 15 p. m., a caravan was sighted, and thus was reassured as to its tats only after we had gone a fair distance. The sunset of this day was an imposing sight.

"Heading for Khartum, we kept onto our course, at an altitude of 5,400 ft., till 2.50 a. m., Nov 23, when we received a wireless order, transmitted by Nauen, from the Admiralty, directing us to return home. Every man was so low spirits when this order was posted in the gangway, for considerably more than half of the way had been conquered, and now all was stopped so suddenly.

"The return trip passed as uneventful as the outward voyage, by 6 p. m. we again sighted the oasis of Farafrah, and at 8 30 p. m. that of Dakhel. At daybreak we were already flying over the Mediterranean and sighted there towards 10 a. m. some freighters, protected by British convoy vessels. The change in temperature now became rather marked and unpleasant. While we experienced on the afternoon of Nov 23, at an altitude of 7,500 ft., a temperature of 32 deg. Cent., and wore tropical uniforms, ten hours later we had to put on our leather suits as the temperature had dropped to 12 deg. Cent.

"At 1 p. m. we sighted Cape Cheledonia 20 miles to north, and reached at 2 20 p. m. Asia Minor, near the city of Adalia, which we passed at the safe height of 9,000 ft. At 3 o'clock we passed Teke, at 5 Simar and towards 11 p. m. Constantinople and alighted at 8 10 a. m. on the following day (Nov 25) in Jamboli after having gone through an icy night."

The author of this narrative appears to be the only surviving participant of this record breaking trip of 4,500 miles, because the L59 was shot down in flames on April 7, 1918 in the channel of Otranto, all of the crew perishing in the fall

From Rome to England

Some time ago the Naval Airship Section of the Royal Air Force decided to purchase from Italy a semi-rigid Forlanini airship in order to obtain experience in a design which is little known in Great Britain. Therefore, a crew, comprising three officers and six ratings belonging to the R. A. F., was sent to Italy to fly the airship to England

They left Rome at 4 25 in the morning of Oct. 29, and made off in the direction of Marseilles, which they intended should be the first stopping-place. After a flight lasting 10 hr and 25 min., which was completed without incident—except that very bumpy weather was experienced over Civita Vecchia, and later on a rainstorm was encountered—Marseilles was reached.

Unfortunately, there was no shed sufficiently large to house the airship, it was, therefore, moored in the open. The crew then had the task of replenishing the fuel supply, and, as very little outside assistance was available, it was a laborious task. However, at 2.50 a. m. (Oct 30), a start was made to complete the second stage of the journey, but there was a head-wind, against which they made poor progress. It was not very long before one of the engines gave out, but the other two were run at full pressure, and half an hour later the third was re-started. The weather conditions were sought by wireless, but no reply was received

The airship kept on toward its objective, Paris, but the strength of the wind increased, and there was not sufficient gasoline to complete the flight. Therefore, the crew turned back and again landed, after being 9 hr in the air, at a French airplane station. There were more troubles there, as the ground staff were not used to handling airships and, therefore, were not of very great assistance

However, by the hard work of the crew, 300 tubes of hydrogen were put into the envelope and 307 gal of gasoline were taken on board. All this time the airship was moored in the open to a 3-ton motor truck

The night was bitterly cold and very damp, the lowest temperature in the car being 1 deg. Centrigrade. All was ready for a start at 3 30 a. m. the next morning (Oct 31), but owing to retractory engines—caused by the cold—the start was delayed until 5 a. m. The morning was dark, with a thick mist, and as the lighting accumulators had not been re-charged during the night, hand lamps were used.

On the way to Paris efforts were made to get in touch with several places by wireless, but no replies were received. However, at 3 p. m. a landing was made at an airship station outside Paris, but this shed was too small to accommodate the airship, which necessitated another night being spent in the open

The following morning (Nov. 1) the airship started at 6 15 a. m. At 7 55 they attempted to call up Havre, Boulogne and Polegate to get weather reports, but again they received no replies. At 8 15 they sighted the coast, which was only visible occasionally, and followed it along to Dieppe. Then they crossed the Channel, and at 12 25 sighted the coast of England. It was only then that they received orders as to their destination, and at 2 15 p. m. made a successful landing

A Goodyear Airship Type

By Herman T. Kraft

Assistant Aeronautical Engineer, the Goodyear Tire & Rubber Co

The Goodyear Tire and Rubber Co during the World War constructed military airships to the limit of its production capacity. These ships varied in size from 75,000 cu ft to 170,000 cu ft capacity, the overall length of the biggest ship being slightly under 200 ft

Fig 1 illustrates an airship of 95,000 cubic feet capacity, which was completely designed by the Goodyear Tire and

FIG 1. A GOODYEAR AIRSHIP ABOUT TO LAND

Rubber Co. The length of the gas bag is 162 ft., the diameter at the greatest cross-section being 33 ft 6 in. The car is 18 ft long and is equipped with a 150 hp. Thomas engine. Seating capacity is provided for six, but the regular crew generally consists of three or four. The ship was designed to have a cruising radius of approximately 12 hours at full throttle, but the endurance can largely be increased by decreasing the engine speed. This ship makes a speed of 56 m.p.h. with full load. On its initial test flight a 12-hour trip was made by flying from Akron, Ohio, to Detroit, Mich., back over Lake Erie to Cleveland, and then back to Akron, and numerous flights of less duration have been made in the past few weeks

All ships are provided with parachutes, which are mounted on the under side of the car, free from entangling parts that may protrude and cause an accident in case a descent is necessary. Though no need ever arose to use parachutes during the operation of these ships, for purely experimental purposes numerous passengers have jumped free from the car and landed safely.

The pontoon arrangement, shown in Fig 3, affords a cushion effect in landing and also permits landing to be made on the sea, where such a ship can rest without difficulty, and whence it can again take off at will

As fuel is consumed by the engine, the lift of the ship increases, and this must be compensated for by letting out gas

FIG 2 GOODYEAR FINGER PATCH SUPPORTING A WEIGHT OF 2000 LB.

from the gas bag, or by taking on some ballast to counteract this tendency. Taking on ballast over land is difficult, but over water it is accomplished as follows: the airship is brought down to within 50 to 100 ft of the surface of the sea, a water ballast pump attached to the lower end of a hose is thrown out and allowed to pass over the surface of the water. The pump is rotated by this action and forces water up the hose into the car, thereby taking on water ballast and getting the ship back into equilibrium without the necessity of sacrificing costly hydrogen gas. The water ballast which is taken on during flight is kept in reserve until the landing is made, when gasoline is transferred to the car to replace the water taken on during flight.

The longitudinal balance of the airship is controlled by shifting air in the ballonets. When the ship is under power, the dynamic effect on the surface of the bag is such that no ap

preamble amount of longitudinal oscillation is noticeable, it is only when the engine is slowed down that one can tell exactly how much the ship is out of balance, and the ballonet is then used for restoring the trim

The mechanical equipment of the gas bag consists of air valves, gas valves and dampers. The air valves are located on this particular ship in the ballonet and are about 18 in in diameter. These valves are set to operate at a pressure of 1.5 in. of water, and weigh approximately 16 lb. each, they are

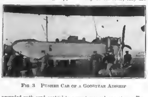


Fig 3 Pusher Car of a Goodyear Airship

provided with cord control to permit manual operation. Two valves are also located in the gas bag proper to relieve the pressure in case an altitude flight is being made. The latter valves are set to blow off at a pressure of 2 in, instead of 1.5 in., as the object is to discharge all the air from the ballonets before the gas is let out. Ordinarily, climbing to 3000-4000 ft altitude is performed by maneuvering the ballonet valves, provided the ballonets contain air; the gas valves are used only when the ballonets are completely deflated. The dampers are T-shaped valves located above the scoop. These valves serve to distribute the air to the proper ballonet when descending, and in some cases are automatic during flight. Manual control is also provided so that the air can be transferred either to the forward or rear ballonet in order to bring the ship into proper balance.

The suspension of the car to the gas bag is of the finger patch type, by means of which the stresses are satisfactorily radiated to the fabric, the object being to distribute the load of the car over as great an area as possible.

Fig. 2 shows a weight of 2000 lb. suspended by one patch, which corresponds to more than the total weight of the car without fuel or ballast. Since there are approximately forty patches of this type around the gas bag, a very large margin of safety is afforded by this type of suspension.

Ballast valves are provided on both gasoline and water tanks. During flight no ballast need be released, providing the ship has gained a positive lift or a negative weight of 500

Fig. 4 Balanced Rudder of a Goodyear Airship

lb. or more. The dynamic effect permits the ship to be flown at any desired altitude and no compensation needs be effected by trimming the ship into balance until a landing place is selected. At this point the engine is throttled to 400 or 500 r.p.m. and the statoscope is read to detect whether the ship is heavy or light. In view of the large fuel consumption of the power plant, the ship is in general liable to have a positive lift of from 150 to 200 lb., according to the flight duration, which makes it unnecessary to release any ballast in any but high altitude flights.

The blower arrangement for forcing air into the ballonets consists of a small Sturtevant fan driven by an electric motor. This is only an emergency device and is used in the event the engine should go wrong at high altitude. In this case the blower is brought into use as a means of inflating the ballonets to permit the ship to be brought back to sea level fully inflated. During regular flying the air scoop takes care of all necessary ballonet requirements and, consequently, the blower is used very seldom.

Leak and Explosion Proof Gasoline Tank

By Glenn D. Angle

Among the inventions of military importance which were held secret during the world conflict and are now being released by the Government for publication is a gasoline supply tank for aircraft which is proof against leak or explosion when pierced by bullets. Unlike most war inventions, its purpose is to preserve life and not to destroy it, and, as will be pointed out later, will also serve its purpose well during times of peace

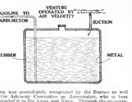
The airplane for warfare had been generally thought of as a reconnaissance machine, but the first few weeks of the war demonstrated that it was also of great military value for both offensive and defensive purposes. Machine guns were immediately installed and aerial warfare became a reality. The combatants quickly realized that the vital spot to be aimed at was not so much the pilot as the gasoline tank, which offered a much larger and easier target to hit. The loss of fuel either forced an untimely and sometimes disastrous landing, or the leaking gasoline, when mixed with the current of air from the propeller, formed a veritable explosive mixture which, when ignited by the engine, set fire to the machine and burned its occupants in midair

To counteract this the Germans, having comparatively heavier planes and higher powered engines, soon resorted to armor plating their tanks, while the ingenious French engineers devised compartment fuel tanks in which one compartment could be pierced and emptied without affecting the others and the supply to the engine was thus maintained. But war is a game of wits and no sooner had the enemy discovered the French methods than he created and employed incendiary bullets. These bullets owe their inflammability to the presence of phosphorus which when mixed with the oxygen of the air will ignite any explosive mixture with which it come in contact

These bullets were fired within a fraction of a second alternatively with armor piercing and tracer bullets, the order and number of each depending upon the kind of attack that was to be made, for example, we may consider the following order. The tracer bullet, leaving a fine trail of smoke, guided the gunner's aim. The armor piercing bullet put a hole in the gasoline tank, causing the fuel to be spilled and to be ignited by the incendiary projectile which followed. This method of attack was very effective and the allied casualties increased alarmingly. The compartment tank used by the French airmen was now of no avail because if one compartment was set on fire the others soon exploded, due to the heat. In the meantime the British had availed themselves of another French invention which consisted in enveloping the gasoline tank with some

elastic material. This minimized the tear caused by a striking bullet but proved only small protection against the incendiary projectile. To get an idea of the vicious character of these bullets, cases have been known where some of the phosphorus became imbedded under the gasoline in the tank and hours afterward when the fuel ran low and the phosphorus became exposed to the air an explosion took place.

This was the state of affairs when the United States entered the war and the problems were immediately taken up by the Bureau of Standards at Washington. The Bureau in turn took the matter up with a Detroit automobile engineer, Fred Weinberg, who had invented a new leak and explosion proof tank and it was demonstrated to the Washington authorities in Aug. 1917, one week after the request was made. The value of the



invention was immediately recognized by the Bureau as well as by the Advisory Committee on Aeronautics, who in turn recommended it to the Army and Navy. Through the co-operation of the Bureau of Standards and the Science and Research Division of the War Department the invention was soon brought to a state of high perfection

The construction of the Weinberg tank is clearly illustrated in the accompanying diagram. Primarily it is an ordinary metal tank of any size or shape having two connections and its filler cap. The suction connection is to provide a partial vacuum above the liquid sufficient to prevent its escape against the pressure of atmosphere on the exterior. This can be accomplished in a number of ways but the simplest method is undoubtedly by means of a venturi in the draft of air while the airplane is in flight. The fuel reaches the carburetor through the second connection by overcoming the vacuum created through the former. This may be accomplished by maintaining greater suction or by positive feed pumps, preferably gear or vane type, mounted on the interior of the tank. To insure proper functioning at all times the tank is enveloped in some elastic material, preferably rubber, which covers any ragged holes in the metal that a bullet might make upon entering. This covering, due to its elasticity, returns practically to its former state after being pierced and leaves a hole so small that it can hardly be detected. The tank may be literally made a sieve by bullet holes and still function properly.

The principle of operation is quite analogous to a very simple example. Almost everybody is familiar with the fact water will not pour out of the neck of a bottle if the latter is turned upside down quickly. This is due to the partial vacuum above the fluid which will hold the liquid in the bottle until the vacuum is destroyed by the entrance of air. The simplest way to do this is to pour the liquid out with the bottle in a horizontal position or to provide a second opening such as we are accustomed to make before we pour milk out of a can. The air entering one hole allows the fluid to flow out of the other. It follows that if we desire to keep the fluid in the can all we have to do is to maintain sufficient partial vacuum above the liquid regardless of how many holes the can may have. This is what Weinberg did and he produced a vacuum in a very simple way by the speed of the airplane itself

The application of this principle not only makes a tank leak proof but makes it explosion proof as well, for to cause an explosion there must be a combustible mixture of air and fuel, whereas in the Weinberg tank no such condition exists on account of the rarefied air. The flames starting on the outside of the tank from an incendiary bullet are immediately drawn into the tank through the bullet opening and are extinct below the fuel. Any bullet striking above the fuel cannot cause ignition by reason of the vacuum existing there. In fact the inventor in testing his tank originally had no incendiary bullets at his disposal so after shooting holes into the tank he directed a torch against the openings made by the bullets.

It has been discovered that a bullet rarely goes completely through a tank. In most cases it will penetrate one side and will lose its energy so completely while passing through the liquid that it will drop into the tank. It may be paradoxically but truly asserted that the fuel tank which formerly constituted the greatest danger to the pilot has now become his best bullet-proof protection

The final tests were made at the aviation experimental station, McCook Field, Dayton, Ohio, in the following manner. Two identical tanks, one made according to the Weinberg invention, the other covered with elastic materials prepared by the Science and Research Division of the War Department, were shot at side by side with armor piercing and incendiary bullets. The latter tank caught fire after the third shot while the Weinberg tank was penetrated by fifteen armor piercing bullets which were followed by seven incendiary bullets and neither leak nor explosion occurred. The test was conducted under the auspices of the Bureau of Standards and was witnessed by the authorities and many scientific experts

Waterproof Glues for Plywood

The Government aircraft program developed a large demand for waterproof glues for plywood which could not be fulfilled with the facilities available. There were several secret waterproof glues in use, of both the blood albumen and the casein types, but the former were not available to outside manufacturers and the use of the latter had not been developed sufficiently to allow a sudden increase in waterproof plywood production

The Forest Products Laboratory at Madison, Wis., was of direct assistance in stimulating the production of the materials needed for making waterproof glues as well as the glues themselves and helped a number of concerns develop satisfactory manufacturing procedure. By continuously testing samples of plywood submitted by manufacturers and helping those who were having trouble, much was done toward securing the production of sufficient quantities of a superior grade and preventing abnormal increases in price. In fact reduced prices made possible a direct saving to the Government of several million dollars, and, what is of even greater importance, limitations in the supply of plywood were eliminated as a controlling factor in airplane production

Methods were developed for the analysis and test of waterproof glues and their components and specifications for them were prepared for the Army and Navy and were adopted for use

Several types of waterproof glues, both of the blood albumen and casein types were worked out and were demonstrated to certain manufacturers upon request of the United States Bureau of Aircraft Production. One of these types is now obtainable upon the open market. A special type of glue tissue for use with very thin plywood was developed and demonstrated commercially. This tissue permits the successful manufacture of very thin plywood, heretofore a very difficult problem

Aluminum Plated Airscrews

A waterproof coating for airscrews, which incorporates a plating of thin aluminum leaf in the finish, has been developed by the Forest Products Laboratory at Madison, Wis., and placed in production by the War Department. The process is practically 100 per cent effective in preventing absorption of water, particularly in the storage stage.

A French authority states that 80 per cent of the French airscrews produced are rejected by the pilots mainly because they are out of balance. This difficulty is due largely to unequal absorption or distribution of moisture and can be greatly reduced by an effective waterproofing coating.

News of the Fortnight

Aeronautical Exposition

The first annual Aeronautical Exposition of the Manufacturers' Aircraft Association, which opens at Madison Square Garden and the 69th Regiment Armory on March 1, and will remain open till March 15, will constitute one of the most representative public expositions of aircraft ever held in the United States.

Beside a large number of American and foreign aircraft there will be on show a vast material of Army and Navy airplanes, seaplanes, airships, kite-balloons, etc. Among the more notable exhibits will be the huge naval seaplane NC 1 and the smallest naval machine, the Loening "Kitten," the Curtiss triplane scout, the original Wright and Langley airplanes, Glenn L. Martin, Caproni and Handley Page bombers, DH-4A's, an F 5-L flying boat, a model of a rigid naval airship, French Caquot and Barrage kite balloons, Nieuport and Spad pursuit machines, etc.

Besides the United States Army and Navy, among the exhibitors of airplanes, airships and engines will be Dayton Wright Airplane Co, Curtiss Aeroplane & Motor Corp, L W F Engineering Co, Wright-Martin Aircraft Corp, Aeromarine Plane & Motor Co, Thomas-Morse Aircraft Corp, Burgess Co, Gallaudet Aircraft Corp, B F Sturtevant Co, Packard Motor Co, Lawrance Aero Engine Corp, Gio Ansaldo & Co, Goodyear Tire & Rubber Co, L Sperry Aircraft Co, Glenn L. Martin Co, Boeing Airplane Co and Cantilever Aero Co.

Among the accessories exhibitors will be Empire Art Metal Co, Arthur Johnson Mfg Co, Dodge Mfg Co, Valentine & Co, Zenith Carburetor Co, Wellington, Sears & Co, John A. Roebling's Sons Co, Eastman Kodak Co, Motor Compressor Co, Cold Light Mfg Co, Livingston Radiator Co, American Balsa Co, Jones Metrola Co, Champion Ignition Co, Dayton Engineering Laboratories Co, Ajax Auto & Aero Sheet Metal Co, Stone Propeller Co, Aerial Age, Splitdorf Electrical Co, National Cash Register Co, Jamestown Propeller Co, American Propeller Co, Hartzell Walnut Propeller Co, Dayton Wire Wheel Co, Lunkenheimer Co, General Ordnance Co, Society of Automobile Engineers, Gardner Muffat Co, Inc Torrington Co, Simms Magneto Co, Triplex Safety Glass Corp, Radium Dial Co, American Bosch Magneto Co, Sterling Engine Co and Detroit Accessories Corp.

The membership of the Manufacturers' Aircraft Association, with the name of the representative of each, is as follows: I M Uppercu, Aeromarine Plane & Motor Corp, 1881 Broadway, New York City; Grover C. Loening, Loening Aeronautical Engineering Co; ..., Curtiss Aeroplane & Motor Corp, Buffalo, N Y; Harold E Talbott, Jr, Dayton Wright Airplane Company, Dayton, Ohio; Fred Fisher, Fisher Body Corporation, Detroit, Mich; Albert H Flint, L-W-F Engineering Company, College Point, L I; Harry B Mingle, Standard Aircraft Corp, Elizabeth, N J; Benj. S Foss, Sturtevant Aeroplane Company, Jamaica Plain, Boston, Mass; J G White, Springfield Aircraft Corp, Springfield, Mass; A J Siegel, St Louis Aircraft Corporation, St Louis, Mo; F L Moss, Thomas-Morse Aircraft Corp, Ithaca, N Y; George S Patterson, The Engel Aircraft Corp, Niles, Ohio; George H Houston, Wright-Martin Aircraft Corp, New Brunswick, N J, and Glenn L Martin, Glenn L Martin Co, Cleveland, O.

The Exposition will be under the management of a committee consisting of: I M Uppercu, chairman; A H Flint, Fay L Faurote, B A Guy and S S Bradley.

British Transatlantic Airship Ready

According to press dispatches from abroad, a British rigid airship is to attempt the transatlantic flight from England to America as soon as weather conditions are favorable. This vessel is the R.33, a sister ship to one being built by Armstrong, Whitworth and Co, and was constructed by an important armament firm near Glasgow. The airship is said to be 670 ft long, 79 ft in diameter and to have a capacity of 2,000,000 cu ft. The power plant consists of five Rolls-Royce engines giving a total horsepower of 1,250, which gives the ship a full speed of about 70 m.p.h. The useful load is stated to be from 27 to 30 tons.

Applications for Flying Licenses

The Joint Army and Navy Board on Aeronautic Cognizance is now prepared to issue flying licenses to pilots of civil aircraft. The standard application form, which is furnished upon request by Lieut L G Haugen, A S A, secretary of the Joint Board, reads as follows:

APPLICATION FOR LICENSE TO FLY CIVILIAN AIRCRAFT

License for flying civilian aircraft is desired under the following terms and conditions

License to be issued to
Address
Owner . Address
To be operated by
Address
Date of first solo flight made by pilot
Date of designation as Reserve Military Aviator or Naval Aviator (and number)
Service in the U S Army or Navy
(An authenticated copy of a certificate or license as evidence of pilot's qualifications must be submitted.)
Passengers to be carried
Description of aircraft
Condition of planes
Present number of hours each plane has been flown
Description of motors
Condition of motors
Present number of hours of each motor
Means to be taken to insure upkeep of planes and reliability of motors
Number of mechanics to be employed
Purpose for which flights are to be made
Nature of aerial project to be organized (should be supplemented by statement in full)
Financial backing available to initiate and sustain project (should be supplemented by exhibits and references)

References
Name Address
Name Address
Name Address
Territory in which flights are to be made
License to be valid from to
Signature of applicant Date

This application after being properly executed should be sent to THE JOINT ARMY AND NAVY BOARD ON AERONAUTICAL COGNIZANCE Bldg D, 6th & B Sts, Washington D C, L G Haugen 1st Lieutenant A S A Secretary

INSTRUCTIONS TO LICENSEE

(1) All licensed aircraft shall display the license number in contrasting colors placed as follows:

Heavier-than-air craft: On the upper surface of each upper wing and the under surface of each lower wing

Lighter-than-air craft: On the upper half and the lower half on opposite side from upper number

All numbers will be five feet in height and nine inches in width of line, unless chord of wing is less than five feet, in which case height of numbers will equal wing chord with above proportion of width of line

(2) A monthly report is required from the holder of this license, giving the flight duration and number of flights made by the aircraft of this license number

(3) This license is issued by the Board and accepted by the licensee on condition that same may be revoked at any time the Board considers it necessary or desirable to do so

Large Aircraft Deal

The first important step in the development of commercial aeronautics on the American continent was taken when interests headed by Ray U Conger and associated with the United Aircraft Engineering Corp, 52 Vanderbilt Avenue, New York City, of which F G Diffin is president, bought outright from the British Government airplanes, engines and spare parts in Canada valued at $10,000,000.

Included in the material purchased are 350 Curtiss JN4D airplanes, 1000 Curtiss engines of the OX-90 hp type, hundreds of propellers, wings and fuselages, and thousands of spare parts. It will require months, however, to compile a complete inventory. In conjunction with the Curtiss machines it is intended to use a new monoplane, the Stout, which was designed by William R. Stout, of Dayton, Ohio, which the United Aircraft Engineering Corporation is developing. This machine is being built in two types, a weight-carrier and a single-seater.

Airplanes for Forest Patrol

Requisition for ten airplanes for forest patrol purposes in the Pacific Northwest has been made, according to announcement by Clyde R Seitz, supervisor of the Cascade National Forest, with headquarters in Eugene, Oregon. He expects that two machines will be assigned to this city—one for the Cascade forest and the other for the Siuslaw forest—the supervisor of which also has headquarters in Eugene.

Either forest may be reached from Eugene by airplane within an hour.

-uniformity

ANSCO COMPANY

BINGHAMTON, N.Y. January 3, 1918.

RESEARCH LABORATORY

American Bronze Corporation,
Berwyn, Pennsylvania.

Gentlemen:

I am submitting below a short report on Non-Gran Bearing Bronze with a photomicrographic illustration. I am also sending separately a number of duplicate photomicrographs which you may find use for. These photomicrographs were made with the Silverman illuminator. Some of the prints are darker than others in order to bring out the structure of the copper rich cores.

Very truly yours

Alfred B. Hitchins

REPORT ON NON-GRAN BEARING BRONZE

Recently a number of bronzes have been examined microscopically with a view to determining the uniformity of their structure and without doubt Non-Gran Bearing bronze exhibits the most uniform formation of any of the bronzes examined. For the purpose of microscopic examination the bronzes were polished and then etched in the following solution:

Distilled water - - - - - 50 cc
Concentrated ammonia - - 35 cc
Hydrogen (15 vol.) - - - 15 cc

The etching was continued for 15 seconds. A photomicrograph (165 X) is attached to this report and shows the eutectoid constituents and the copper rich cores. After the photomicrographic work had been completed the sample of Non-Gran Bronze was split up into portions and a series of chemical analyses were made. These resulted in a remarkable similarity of the chemical content of the alloy, further confirming the uniformity of the product.

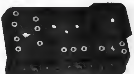
HIGH SPEED
NON-GRAN
BEARING BRONZE

Made by

American Bronze Corporation
Berwyn Pennsylvania

BAKELITE

REG. U. S. PAT. OFF.



Compared with this most moulding is simple

The dimensions of this Bakelite Distribution Box are 7 in. x 4¼ in. and its greatest depth 2½ in. The average thickness of the shell is $\frac{3}{32}$ of an inch.

Lettering and symbols are in very low relief but other raised parts project as much as $\frac{3}{8}$ in. from the surface of the shell proper.

As an additional complication twenty metal inserts were successfully incorporated while the piece was being moulded.

The lustrous finish which the piece has when it leaves the mould cannot be reproduced in an illustration. It possesses, however, that perfect finish which is one of the distinguishing merits of Bakelite.

For many years Bakelite has been in continuous and successful use for the making of moulded insulated parts in innumerable forms.

Bakelite excels in dielectric strength and in its indifference to heat, oils, steam and most chemicals. It is non-hygroscopic and will not bloom, warp, swell or shrink.

The **GENERAL BAKELITE COMPANY,** 2 Rector Street, New York, welcomes inquiries from manufacturers and maintains a research laboratory for the working out of new applications, including those pertaining to flying machines. 2017 R

Protection in the Air—

There are two dangers from which the airman must protect himself while in the air—fire and engine trouble.

The highly inflammable "dope" of the wings makes his machine especially vulnerable to the quick spread of fire, and he must have constant and accurate knowledge of what his engine is doing.

Johns-Manville Service to the aviator provides protection against the possibility of danger from these sources through the Johns-Manville Tachometer and the Johns-Manville Fire Extinguisher.

The Johns-Manville Tachometer

enables the pilot to maintain correct engine speed under various flying conditions. For planes using twin propellers actuated by two engines, the use of Johns-Manville Tachometers also allows the aviator to maintain the same speed on both engines. The Johns-Manville Tachometer is sturdy, accurate and unaffected by changes in altitude or temperature.

The Johns-Manville Fire Extinguisher:

is the only fire extinguisher of any use to the airman for it is the only one that can be operated with one hand only, leaving the other hand free for the stick and throttle.

Pressure may be pumped up beforehand—then with a mere touch of a lever the stream can be directed against the blaze.

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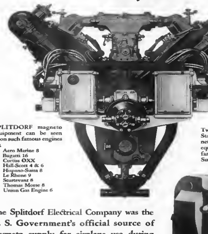

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- Hispano-Suiza 8
- Le Rhone 9
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- Thomas Morse 8
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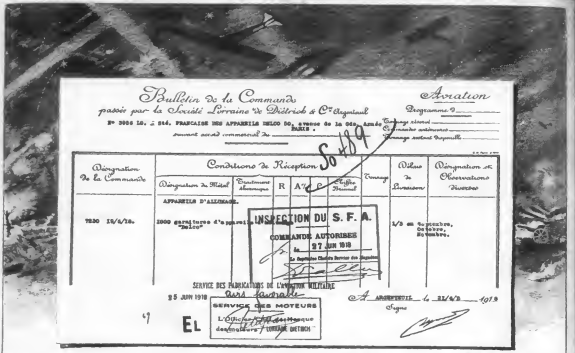

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L'Officier Chef des Masque des moteurs LORRAINE DIETRICH

EL

A ARGENTEUIL le 22/6/8 1918

Signé

Photograph of order issued by the Lorraine — Dietrich Company, countersigned by the French Government, Department of Motors and the Division of Magnetos requiring delivery of 1,000 Delco Ignition Systems to supplant standard magneto equipment on the latest French aeroplane motors.

Such an order was quite unprecedented in Europe of course — but War cannot respect custom nor play favorites. It always demands the fittest and best. So as the war went on, our Veteran Allies, taking their cue from the performance of American battle planes, *also* recognized the supremacy of Delco Ignition for the strenuous airplane service.

The Dayton Engineering Laboratories Company
Dayton, Ohio U. S. A.

Delco

Above: Delco installation on Lorraine — Dietrich motor.

Right: Delco switch used with this type of ignition.